HOW IT WORKS

200 COOL THINGS YOU NEED TO KNOW

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And 24 other weird science facts

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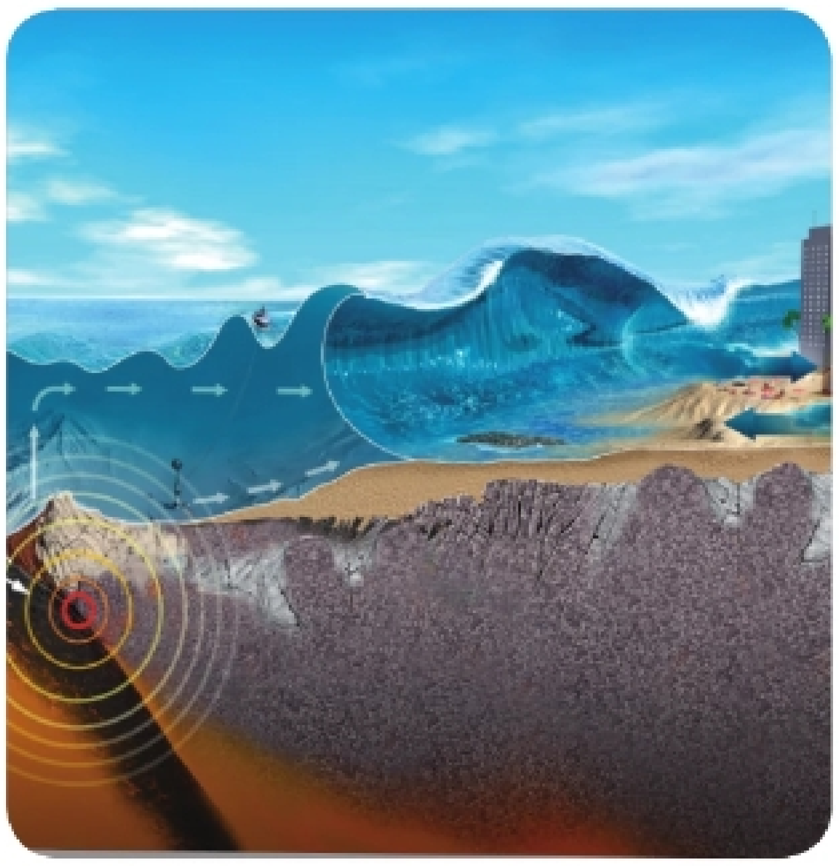

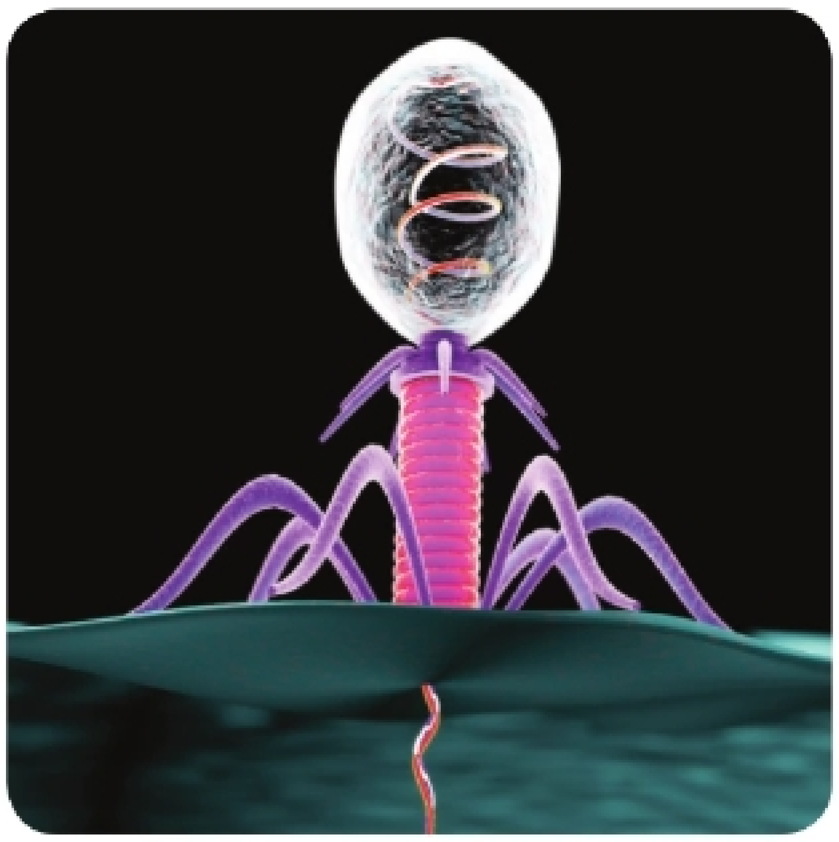

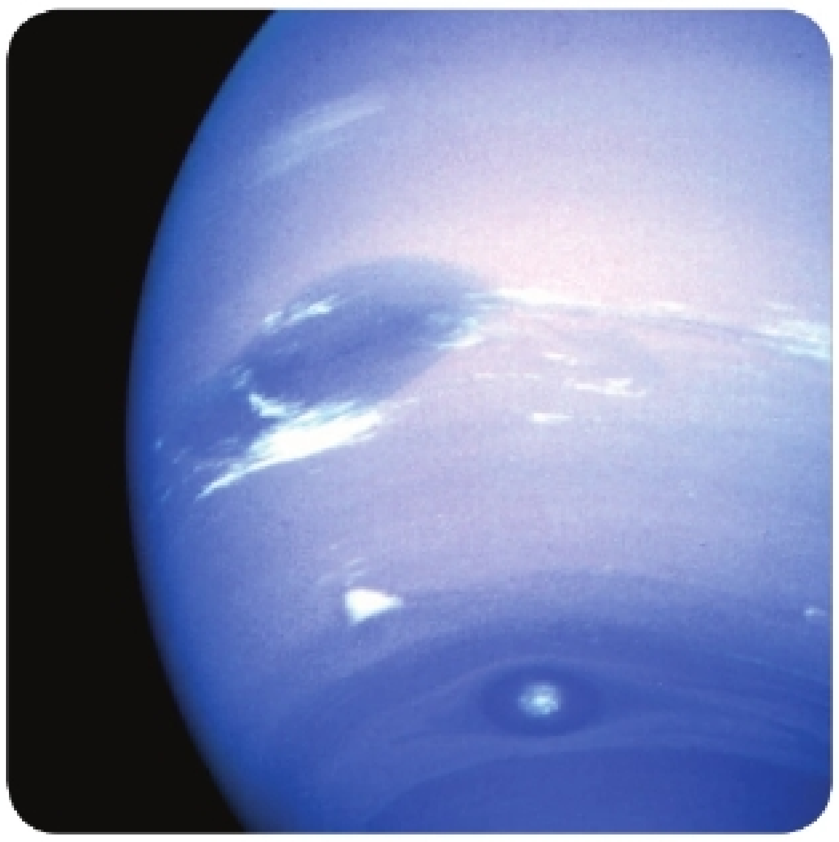

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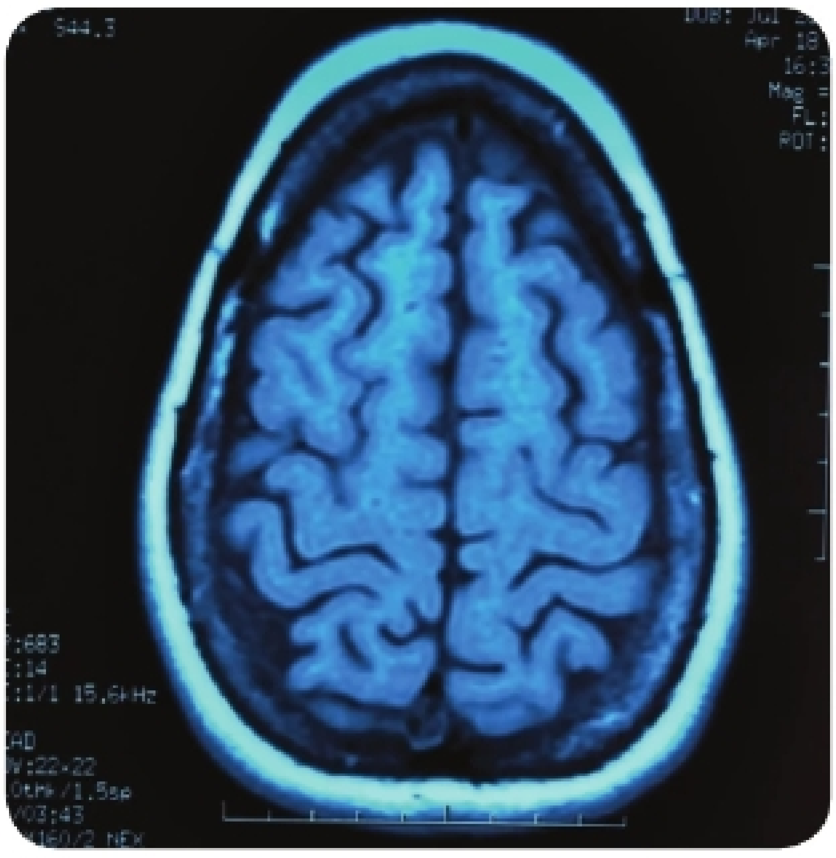
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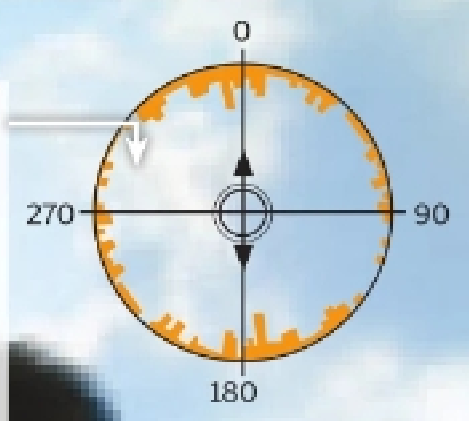
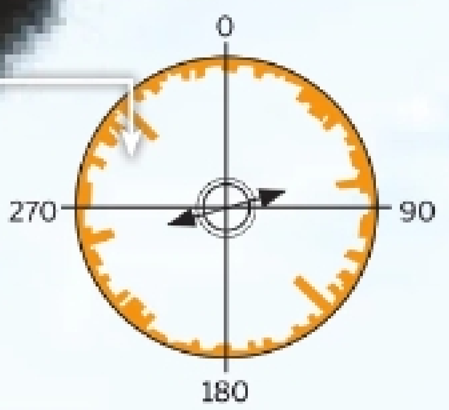
COWS ARE MAGNETIC AND 24 OTHER WEIRD SCIENCE FACTS

NO POWER LINES



Bovine north-south tendency
Cows were most likely to be found with their heads pointing due north or south, aligned with geomagnetic fields.

NEAR POWER LINES



Disorder
In the vicinity of power lines the north-south alignment went awry, presumably because the cables' own weak electric fields disrupt magnetoreception.

Science is full of surprises. From the bizarre habits of fruit bats to the average colour of our universe (believe it or not, it isn't black), the weird discoveries uncovered by researchers across all fields of science are a constant reminder that we know far less than we sometimes assume.

Our world, and indeed the cosmos beyond, still has the capacity to shock us, and what's more, it's these anomalies that keep science moving forward, challenging our assumptions and forcing our understanding to new levels. Just think, once upon a time, even cornerstones of the scientific institution like gravity would have seemed crazy.

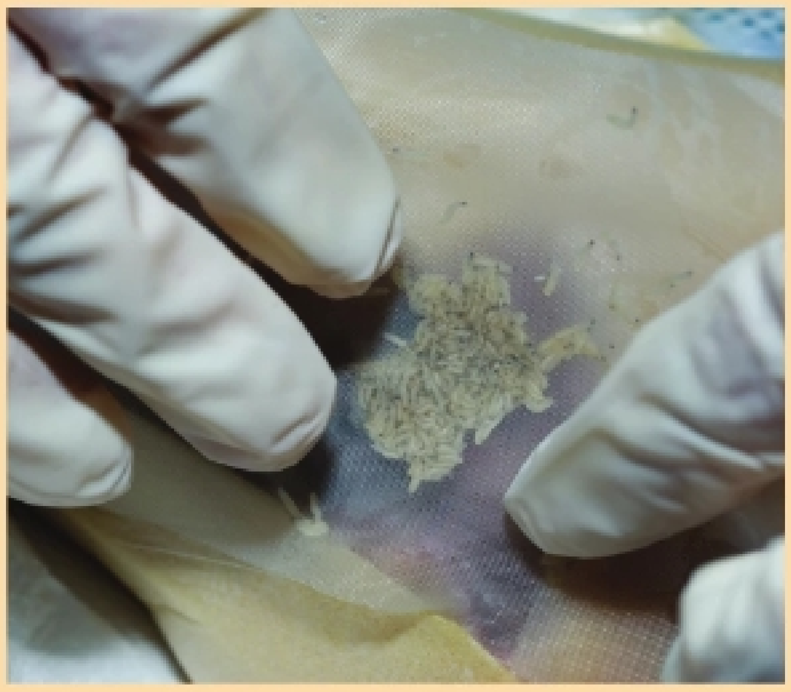
Funny, intriguing or just plain jaw-dropping, here are 25 of science's strangest findings, from marine biology to mathematics and astronomy. You'll never see the world in quite the same way again…

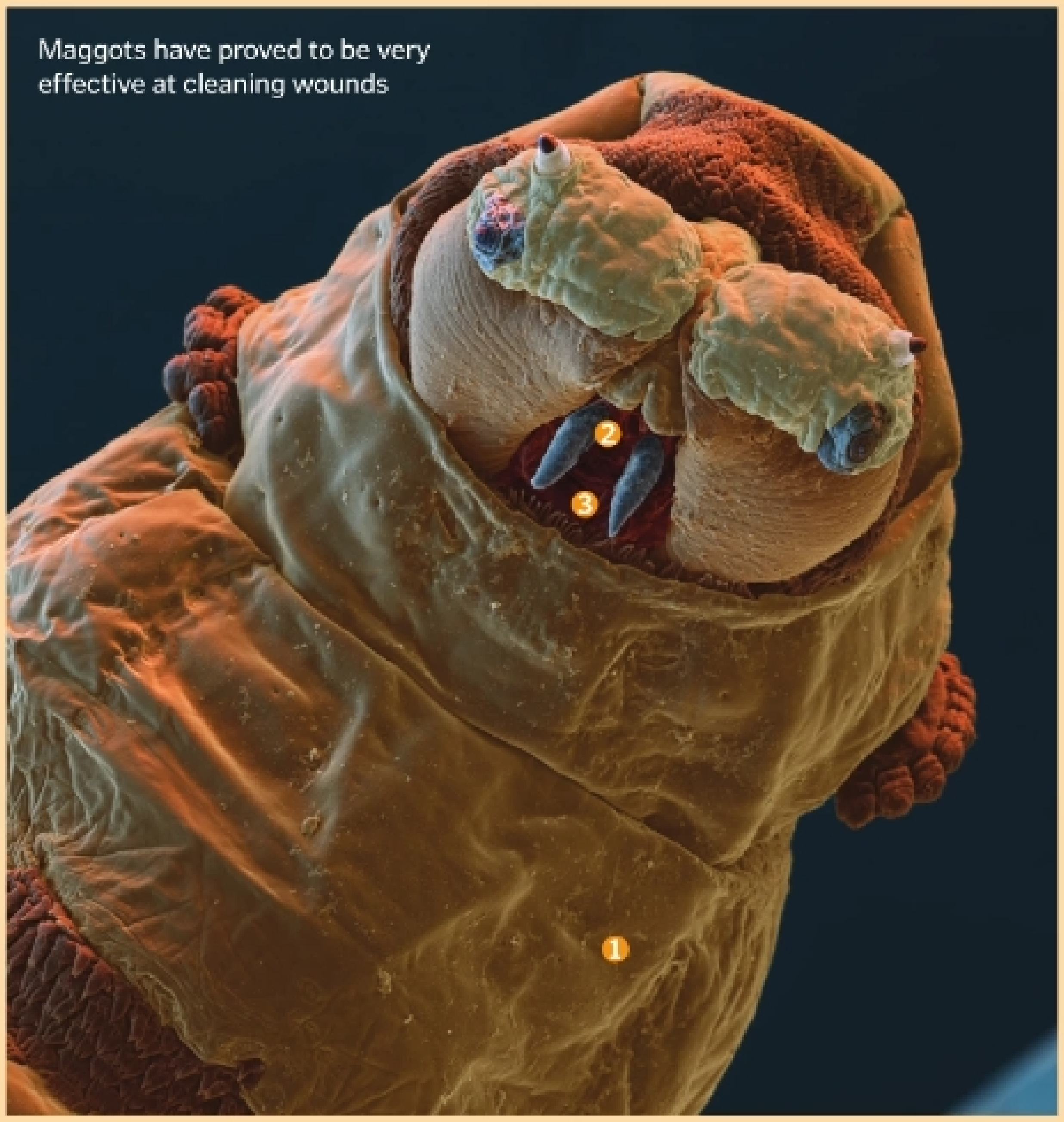
1. Cows are magnetic

Well, technically they're more like compass needles. Studying satellite imagery from Google Earth, researchers found that cattle (and deer) often align themselves with the Earth's magnetic field lines between the north and south poles. They aren't the only ones believed to sense magnetic fields: bacteria, molluscs and mole rats also display a magnetic 'sixth sense'. But while magnetoreception has a clear advantage for migratory animals, it's not obvious how it could benefit cows. One hypothesis is that it may help them to map their local surroundings.

2. Wounds filled with maggots heal faster

In deep wounds and ulcers, dead or dying tissue needs to be cut out at regular intervals to prevent infection – a process called debridement. Eating dead tissue but sparing healthy tissue, applying maggots to the wound can achieve more precise results than the surgeon's knife in a shorter time. On top of that, maggot secretions have a wide range of benefits, from improving the flow of nutrients to healing tissues to raising the wound's pH level to limit pathogenic bacteria growth.




Maggots have proved to be very effective at cleaning wounds

① **Body**
Measuring around a centimetre (0.4in) long, about six maggots are applied for each square centimetre of the wound.

② **Mouth hooks**
Maggots use these two modified mandibles to probe and scratch away at dead tissue.

③ **Secretions**
Enzymes in its saliva and secretions help it to break down its food.

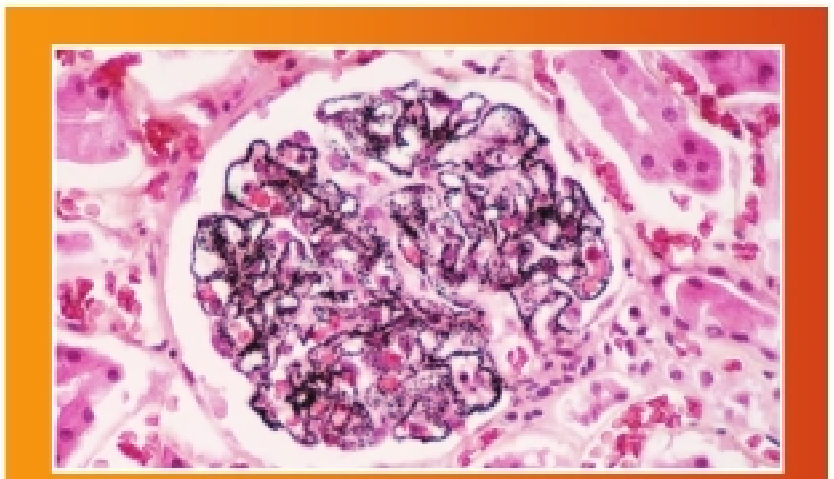
3. Hot water can sometimes freeze quicker than cold water

Observed by scientists as far back as 400 BCE, this uncanny phenomenon is called the Mpemba effect. Several theories attempt to explain it. Concentrations of solutes (which evaporate from hot water) could play a part, or it could be that frost forming on cold water insulates it from further cooling. Convection is also a likely culprit. Inside the freezer, the water touching the container walls cools quicker than water in the centre. This creates convection currents as warmer, less dense water rises. These currents are much stronger in heated water, where the temperature gradient is more extreme, helping it cool faster.

More recent research has implicated that supercooling – the phenomenon in which water doesn't always freeze at 0 degrees Celsius, but continues to cool by several degrees before ice appears – may play a role too. Some believe that initially cold water supercools more than hot water, although why that may be remains to be confirmed.

4. Plants have friends and enemies

Recent studies suggest that plants behave differently depending on who their neighbours are. When surrounded by 'friendly' plants, including genetic relatives or helpful species that limit pests and weeds, they grow slowly, perhaps to share resources. But when they detect a rival such as fennel, which secretes chemicals to inhibit other plants, they grow far more aggressively. Plants recognise these friends and foes thanks to chemical signals emitted from their leaves or roots, and some studies even imply that plants can detect sounds produced by their neighbours. Plants can also alert their fellow flora to attacks from herbivores or parasites. When a tomato plant is attacked by aphids, for instance, it releases volatile chemicals into the air. The plants that pick up on these signals respond by producing their own chemicals to repel the parasites and even attract wasps that prey on aphids. Other species use symbiotic fungi living on their roots as messengers.



5. Too much silver can turn skin blue

Argyria is a condition in which skin turns a blue-grey shade, provoked by ingesting silver. Broken down in the stomach, silver enters the bloodstream as a salt and is deposited in the skin. Light oxidises it, producing blue or grey-silver compounds. Sufferers have usually taken colloidal silver supplements – an alternative remedy with no known benefits.

6. Honey has no expiry date

Honey's low moisture content and high acidity create an inhospitable environment for the bacteria and other microbes that cause food to spoil. It also has traces of hydrogen peroxide, an effective antibacterial agent. If exposed to air, though, moisture can get in, so it needs to be kept in a sealed container to last indefinitely.

7. Straight hair has more knots than curly

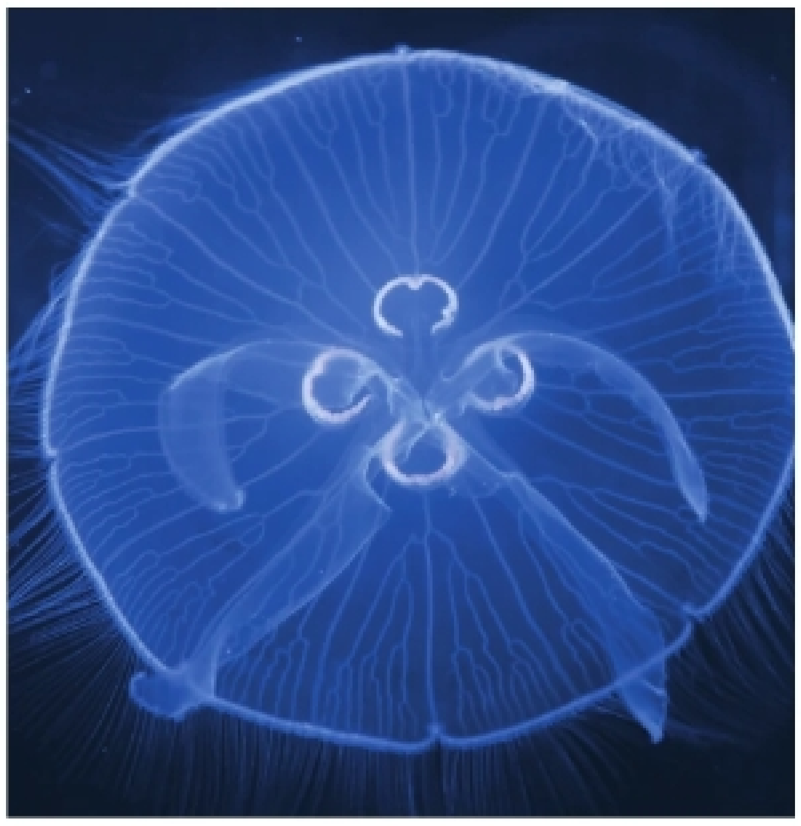
After counting the tangles on hair salon customers' heads, mathematicians found that straight-haired people averaged over five knots, while curly-haired customers had only three. Mathematical models of tangling suggest that although curly hairs brush against each other more often, the angle at which straight hairs meet makes them more likely to become entwined.

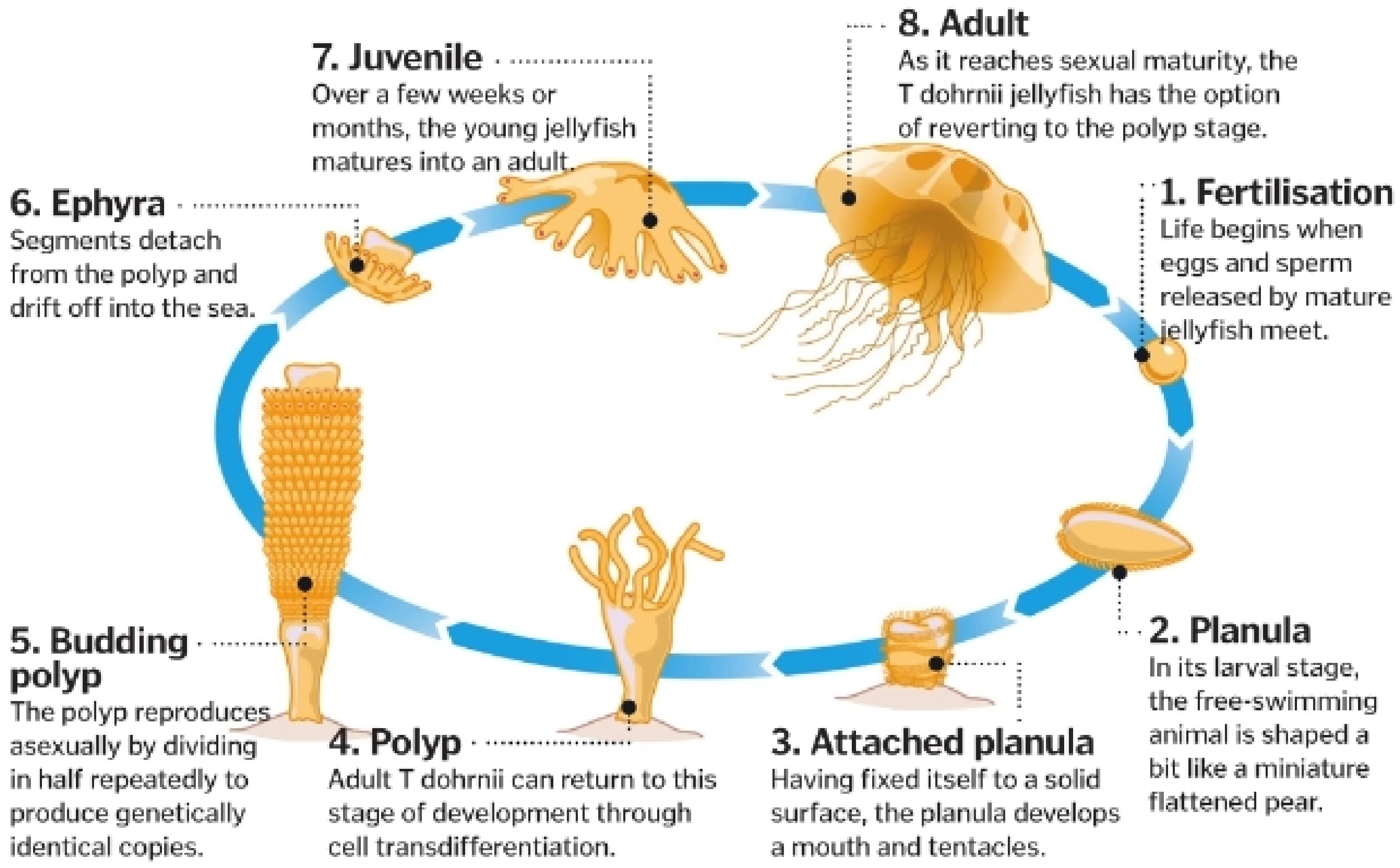
8. The colour of the universe is beige

After adding up the light emitted by 200,000 galaxies, two astrophysicists determined the average colour of universe: a rather bland shade of beige that they nicknamed 'Cosmic Latte'. Ten billion years ago, the universe would have had a pale blue hue, but its colour has shifted with the increasing number of redder stars.

9. Some jellyfish are immortal

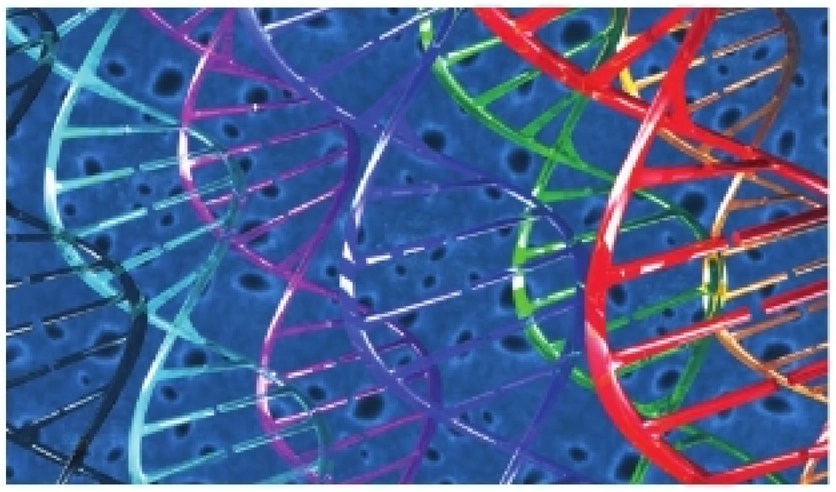
The tiny Turritopsis dohrnii jellyfish has a remarkable life cycle: after reaching sexual maturity it can revert back to a juvenile state. There is no apparent limit to how many times it can do this, meaning it could theoretically live for ever. While most T dohrnii die in the conventional manner, in times of crisis they can transform into a polyp state, a process called transdifferentiation. This lets them reproduce asexually to start a new colony. Unique in the animal world, this has helped them spread to oceans across the world.




8. Adult
As it reaches sexual maturity, the T dohrnii jellyfish has the option of reverting to the polyp stage.
7. Juvenile
Over a few weeks or months, the young jellyfish matures into an adult.
6. Ephyra
Segments detach from the polyp and drift off into the sea.
1. Fertilisation
Life begins when eggs and sperm released by mature jellyfish meet.
5. Budding polyp
The polyp reproduces asexually by dividing in half repeatedly to produce genetically identical copies.
4. Polyp
Adult T dohrnii can return to this stage of development through cell transdifferentiation.
3. Attached planula
Having fixed itself to a solid surface, the planula develops a mouth and tentacles.
2. Planula
In its larval stage, the free-swimming animal is shaped a bit like a miniature flattened pear.

10. There is 0.2mg of gold inside us

We absorb small amounts of gold from our environment, but it serves no known purpose. Largely inert, it is non-toxic in small doses. Gold compound sodium aurothiomalate can, however, reduce inflammation in arthritis patients, although its mechanism of action isn't fully understood. Researchers are currently investigating the use of nanoparticles equipped with antibodies which could latch on to cancer cells to help speed up diagnosis.



11. We can have more than one set of DNA

Known as chimerism, this condition can arise when two eggs are fertilised inside the mother. Instead of developing independently to produce non-identical twins, one absorbs the other, taking on its cells and DNA. The outcome is one individual combining cells with two different genotypes. Most chimeras are oblivious to their genetic makeup, but it can create some strange results. Indeed, they may have two blood types or even organs with different genotypes.

12. A candle flame is full of diamonds

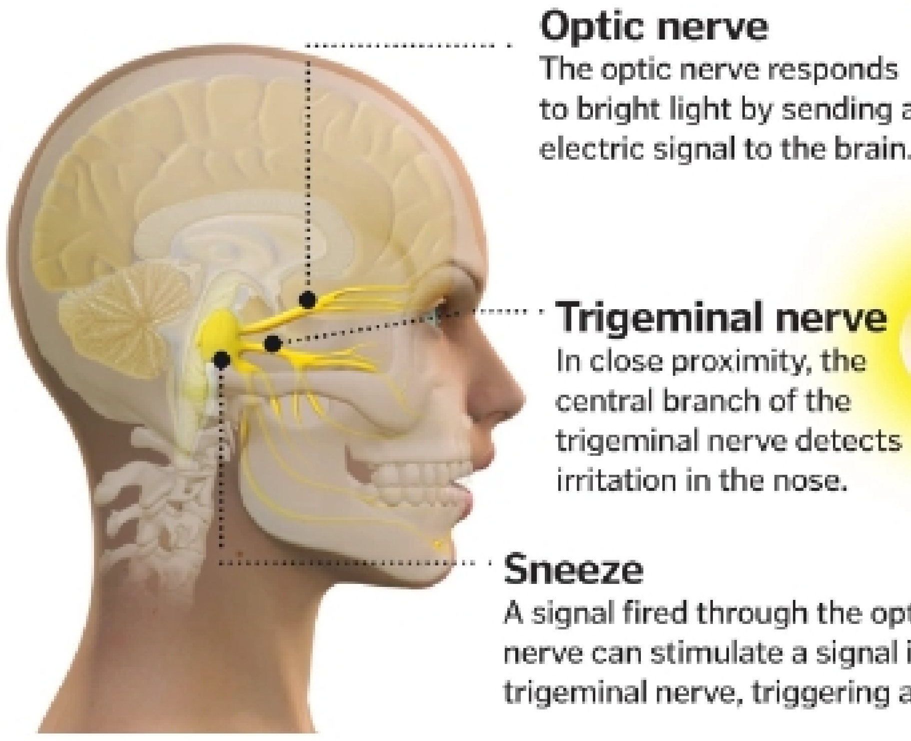
Within a candle's flickering flame, hydrocarbon molecules are converted into carbon dioxide. During this process, the carbon briefly takes the form of diamond nanoparticles. A whopping 1.5 million of these minuscule gems are created every second, but are burnt up almost instantly. Although harvesting these diamonds would be impossible, this recent discovery could lead to new methods for producing cheap jewels. Alongside diamonds, researchers were surprised to find the three other forms of carbon (fullerenic particles, graphitic and amorphous carbon) in the flame.

13. Liquids can defy gravity

When cooled down to near absolute zero temperatures, certain substances such as helium become superfluids with zero viscosity, capable of climbing walls or seeping through microscopic cracks. This occurs thanks to a weird quantum effect which makes individual atoms act as one, flouting both gravity and surface tension. Ferrofluid (pictured) is just as mind-blowing; made by suspending tiny magnetic particles of iron in oil, these magnetic liquids form intricate patterns of peaks and troughs when they are placed in a magnetic field.

14. Light can make some people sneeze

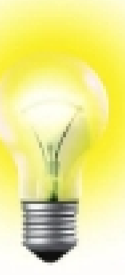
In about a quarter of people, sudden exposure to bright light can bring on a sneezing fit known as the photic sneeze reflex. Normal sneezes happen when something irritates the nose lining. This stimulates the trigeminal nerve and the body expels the irritant with a sneeze. The nearby optic nerve, meanwhile, alerts the brain to changes in light levels, to which it responds by constricting or enlarging the pupils. In photic sneezers, a flood of light creates electric signals in the optic nerve sensed by the trigeminal nerve, triggering a sneeze.



Optic nerve
The optic nerve responds to bright light by sending an electric signal to the brain.

Trigeminal nerve
In close proximity, the central branch of the trigeminal nerve detects irritation in the nose.

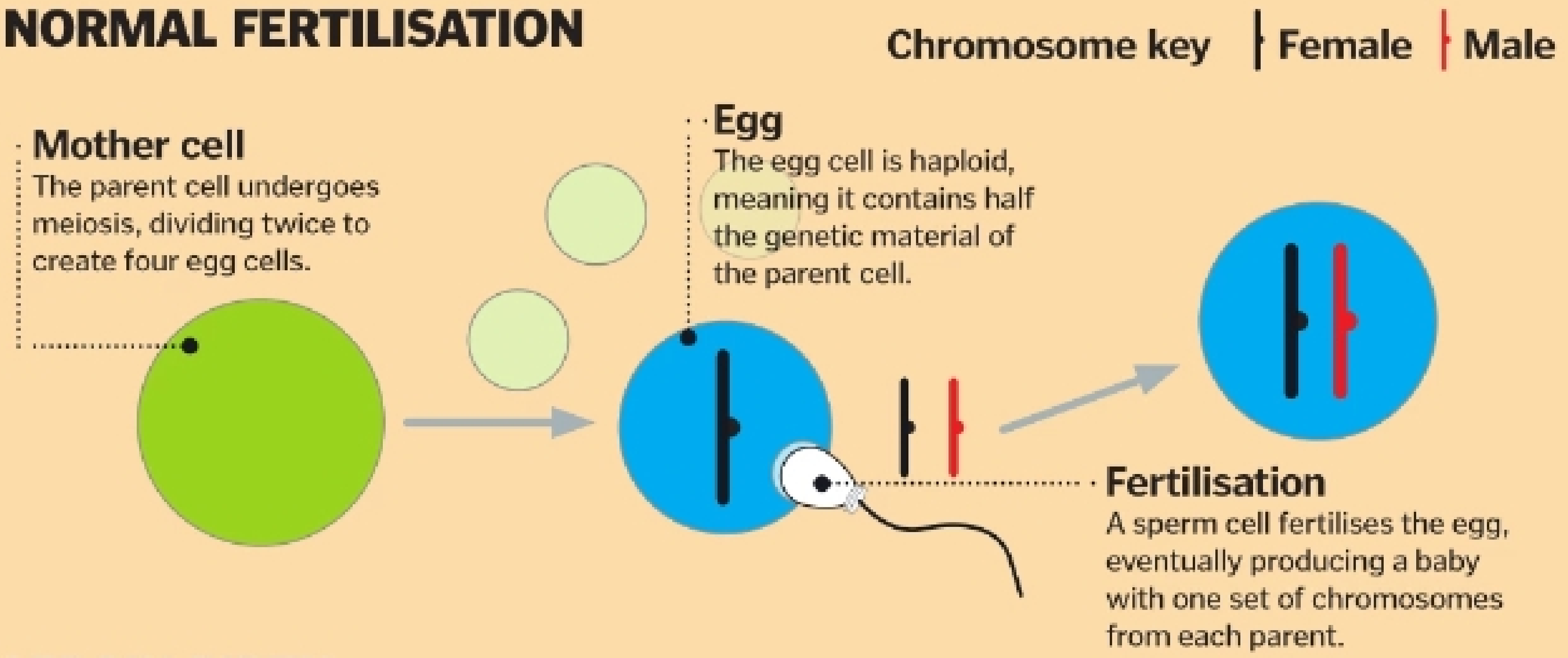
Sneeze
A signal fired through the optic nerve can stimulate a signal in the trigeminal nerve, triggering a sneeze.



15. Virgin births are not a myth

In some species, a female's egg cell can develop into an embryo without being fertilised. This form of asexual reproduction is called parthenogenesis (Greek for 'virgin birth') and occurs in many plants and insects, as well as certain fish and reptiles, including Komodo dragons and hammerhead sharks. Some species reproduce exclusively through parthenogenesis, while others use it as a back-up option when there are no males. In most species, parthenogenesis produces offspring with two identical sets of chromosomes, making them half-clones of their mother.

NORMAL FERTILISATION

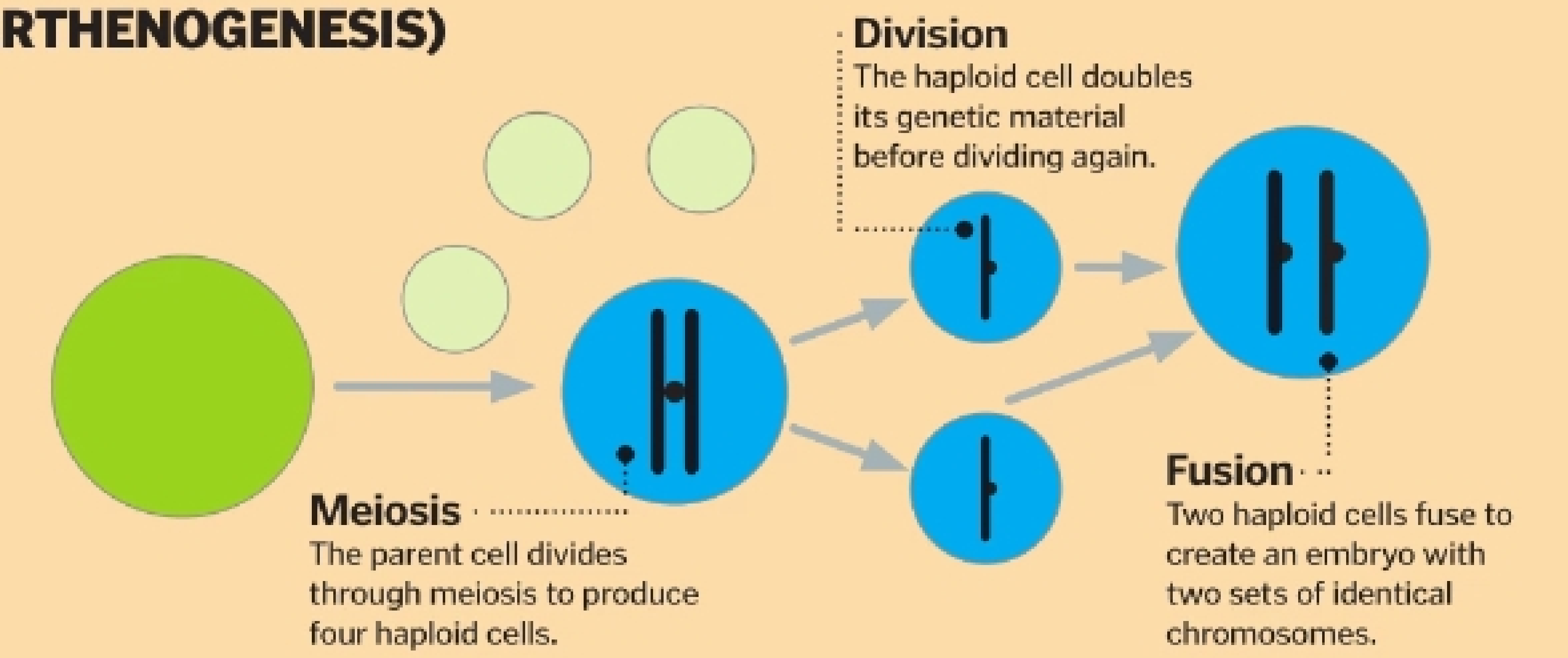


Mother cell
The parent cell undergoes meiosis, dividing twice to create four egg cells.

Egg
The egg cell is haploid, meaning it contains half the genetic material of the parent cell.

Fertilisation
A sperm cell fertilises the egg, eventually producing a baby with one set of chromosomes from each parent.

VIRGIN BIRTH (PARTHENOGENESIS)



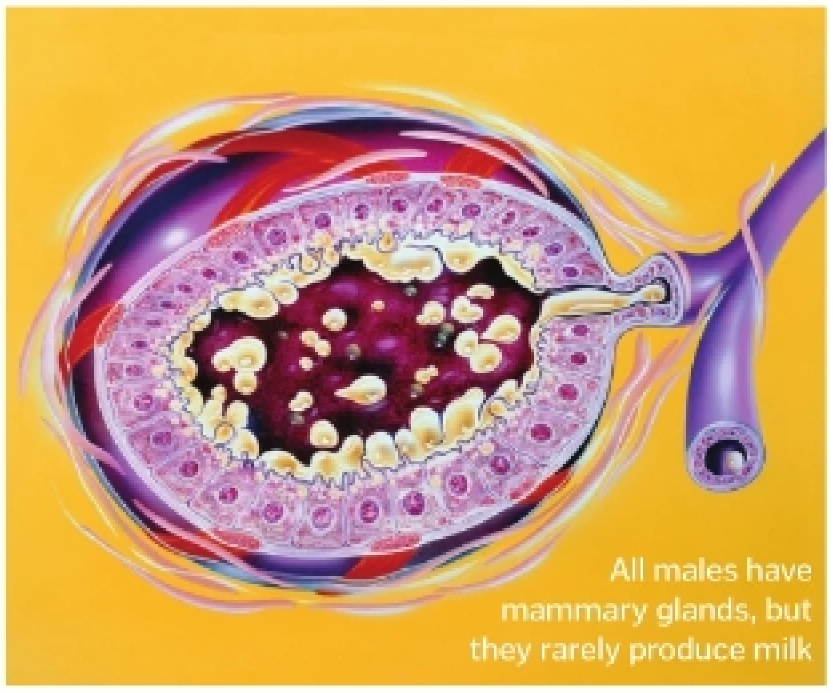
Division
The haploid cell doubles its genetic material before dividing again.

Meiosis
The parent cell divides through meiosis to produce four haploid cells.

Fusion
Two haploid cells fuse to create an embryo with two sets of identical chromosomes.

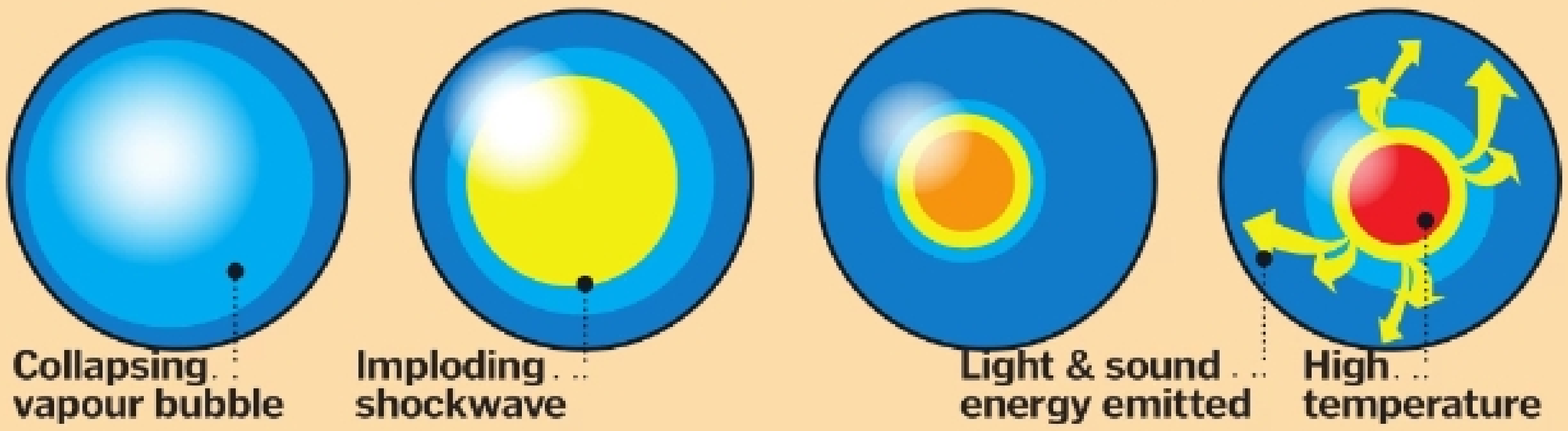
16. Men can lactate too

Male mammals possess mammary glands and can produce milk, although this is rare. Certain disorders involving the pituitary gland, for example, cause it to produce prolactin, which stimulates milk production. The Dayak fruit bat is the only species in which male lactation is widespread. It's unclear whether they actually breast feed or if milk production is a side-effect of a diet rich in phytoestrogens – plant molecules that mimic female hormones.

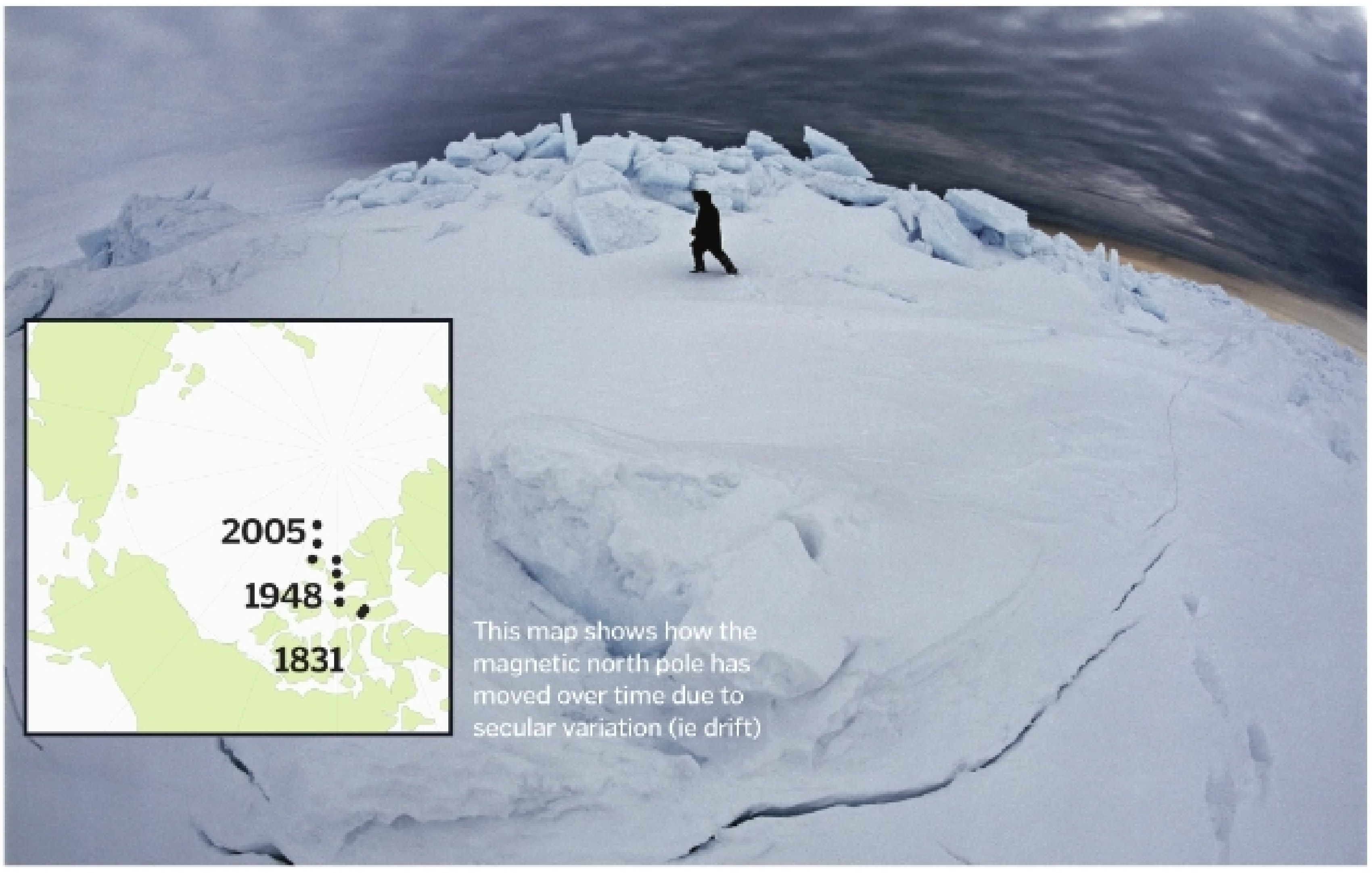

All males have mammary glands, but they rarely produce milk

17. Pistol shrimp snap their claws louder than Concorde

The diminutive pistol shrimp can snap one of its claws so hard that it tears water apart, creating a high-pressure bubble of gas called a cavitation bubble. As it collapses, the bubble creates a deafening pop as loud as 218 decibels, lasting for just one millisecond. Just before it bursts, the temperature inside the bubble soars to 4,700 degrees Celsius (8,500 degrees Fahrenheit), creating an intense flash of light (see diagram below). The shrimp uses this trick to stun prey.



18. There is more than one north pole

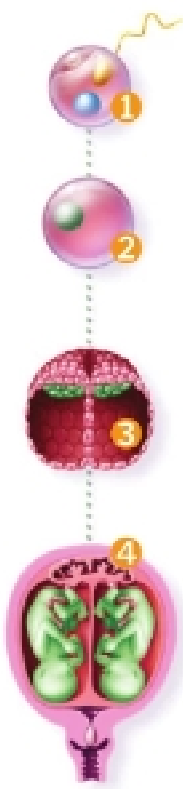


This map shows how the magnetic north pole has moved over time due to secular variation (ie drift)

True (or geodetic) north is a fixed point, located where the Earth's axis of rotation meets the planet's surface, diametrically opposite the south pole. However if you look at a compass needle, it doesn't point to the north pole, but rather to a place a few hundred kilometres south-east: magnetic north. Earth acts like a giant magnet, and the magnetic north is one of its poles. The planet's magnetic field is created by churning molten iron in the planet's outer core. As these currents change, so does the location of the magnetic north pole, which is currently wandering at a speed of about 55 kilometres (34 miles) a year. After drifting through northern Canada, magnetic north is now heading towards Siberia. More dramatic changes could, however, be afoot. In the past, Earth's magnetic poles have switched places every 500,000 years. The reason behind these flips is unknown, but geophysicists predict that the next one could be coming up in a few thousand years.

19. Identical twins are not identical

Although they originate from the same fertilised egg, identical twins still carry small differences in their genes. Examining twin genomes closely, researchers found variations in the numbers of copies of a given gene, possibly caused by mutations during early development. This variation could explain why sometimes one twin develops a genetic disorder while the other is spared.



❶ Fertilisation
A sperm cell fertilises an egg, producing a cell called a zygote which combines the parent cells' DNA.

❷ Zygote
The zygote soon divides to form a small bunch of cells called a blastocyst.

❸ Split
The blastocyst can split into two between one and nine days after fertilisation.

❹ Mutations
As the foetuses develop, 'copy errors' in cell division create small variations in the twins' genetic material.

20. The faster you move, the heavier you get

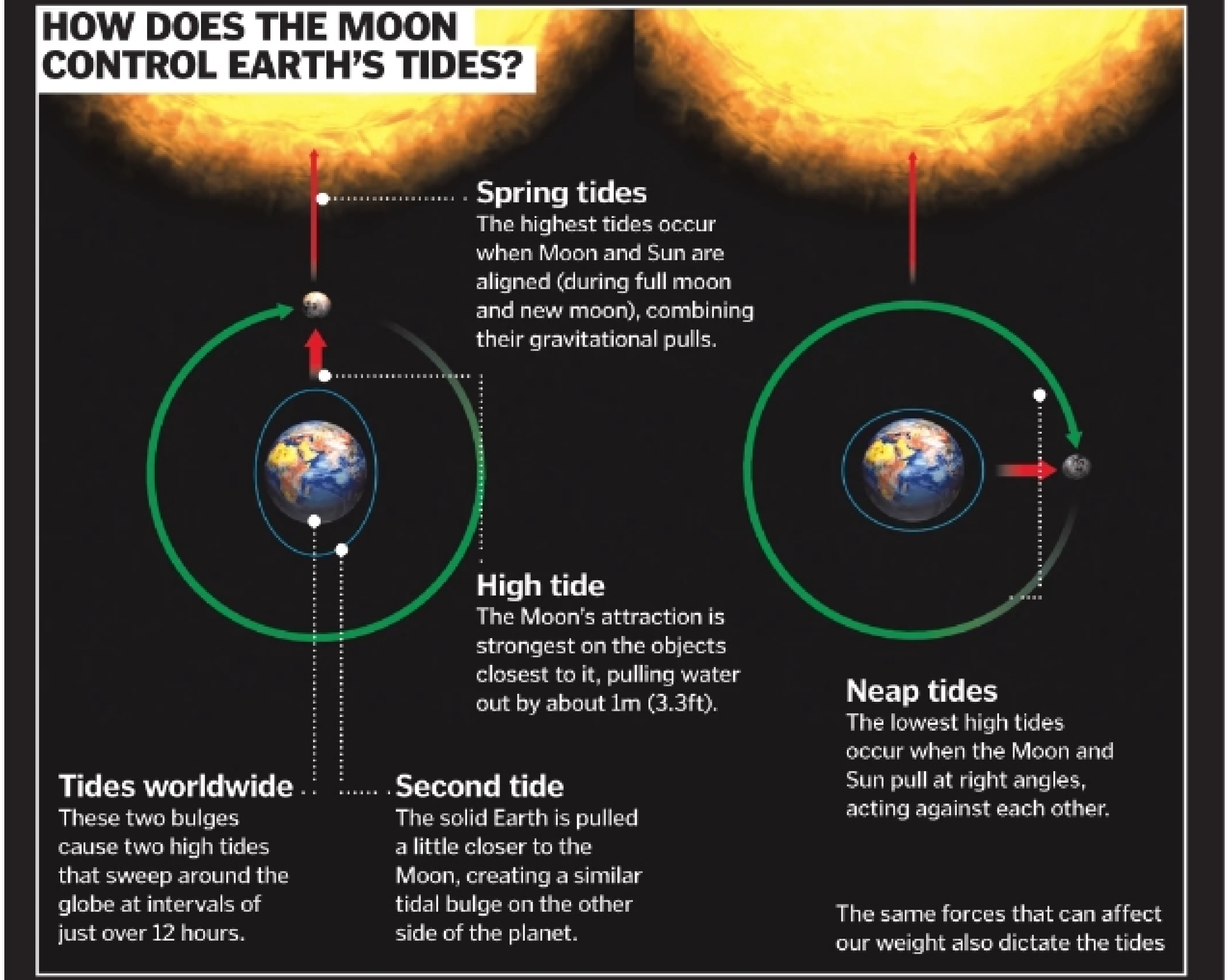
Einstein discovered this with his theory of special relativity. As an object picks up speed it gains kinetic energy, which causes its mass to increase, as described by his famous $E=mc^2$ equation. At the speeds humans travel at the change in mass goes unnoticed, but as an object comes close to the speed of light the effect is undeniable. Particle accelerators like the Large Hadron Collider propelling protons at almost the speed of light, for instance, need to take their increased mass into account. One consequence of this is that no object can travel at the speed of light – the faster it gets, the more mass it acquires and the more energy it needs. In other words, you'd need infinite energy to push it to light speed.

When travelling at high speeds, you become noticeably heavier

21. We weigh less when the Moon is overhead

What we call weight is the downward force resulting from Earth's gravitational pull on our mass. But Earth isn't the only one pulling us towards it. The Moon also exerts a force on us, cancelling out some of Earth's attraction when it is directly overhead. Being much smaller and also farther away from us, the Moon's magnetic field is much weaker, meaning the effect is almost imperceptible: ie a 100-kilogram (220-pound) person would weigh just 0.5 grams (0.02 ounces) less. Conversely, when the Moon is on the opposite side of Earth to you, you weigh a fraction more.

HOW DOES THE MOON CONTROL EARTH'S TIDES?


Spring tides
The highest tides occur when Moon and Sun are aligned (during full moon and new moon), combining their gravitational pulls.

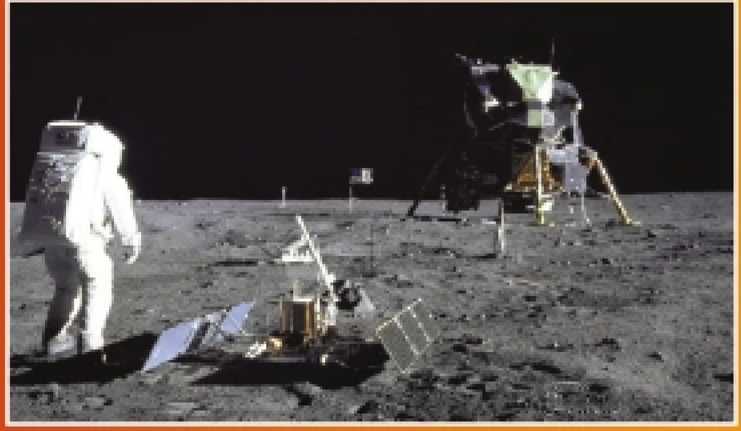
High tide
The Moon's attraction is strongest on the objects closest to it, pulling water out by about 1m (3.3ft).

Neap tides
The lowest high tides occur when the Moon and Sun pull at right angles, acting against each other.

Tides worldwide
These two bulges cause two high tides that sweep around the globe at intervals of just over 12 hours.

Second tide
The solid Earth is pulled a little closer to the Moon, creating a similar tidal bulge on the other side of the planet.

The same forces that can affect our weight also dictate the tides



22. A mobile phone has more computing power than used on the Apollo missions

The Apollo guidance system that successfully landed man on the Moon had just 64 kilobytes of memory and operated at 0.043 megahertz. Modern-day smartphones, meanwhile, average one to two gigahertz, meaning that they are around 40,000 times faster.

23. There are more molecules in a cup of water than cups of water in the oceans

Earth's oceans contain approximately 1.3 billion cubic kilometres (312 million cubic miles) of water, which equates to 5.2×10^{21} 250-millilitre cups. A cup of water, meanwhile, contains a jaw-dropping $8.4\text{x}10^{24}$ H_2O molecules – that's over 1,000 times more molecules than cups!

24. NASA has a building so big that it can rain inside

NASA's Vehicle Assembly Building's vast interior extends over a whopping 3,665,000 cubic metres (129,428,000 cubic feet). On humid days, it can accumulate enough moisture to form clouds – although in practice 125 ventilators keep humidity levels in check.

25. A single-celled organism can be up to 20cm across

Syringammina fragilissima's one cell branches out into a network of tubes extending over ten centimetres (3.9 inches). As it grows, the deep sea-dwelling creature oozes slime onto the sediment, solidifying its structure.

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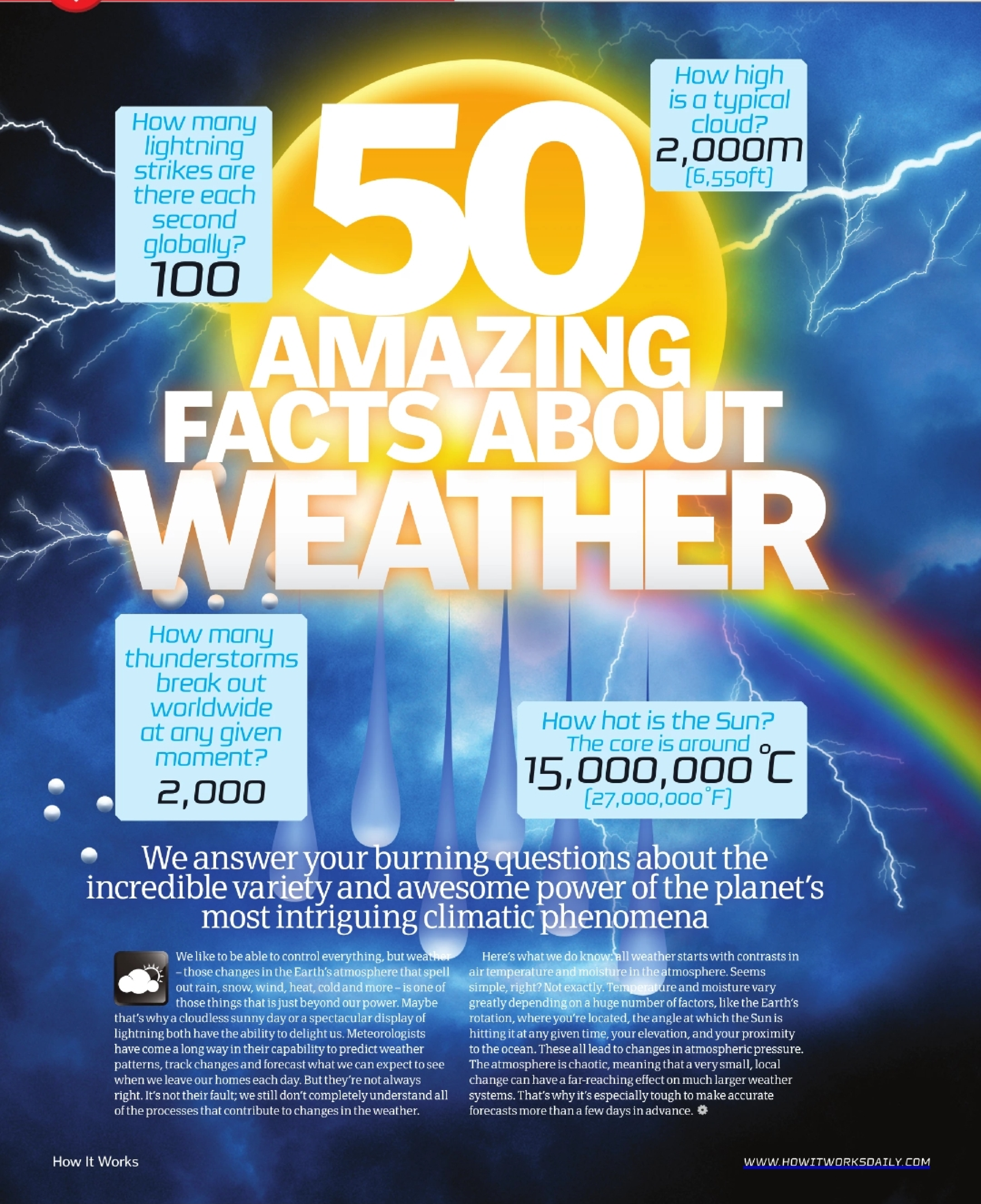


50 AMAZING FACTS ABOUT WEATHER

How many lightning strikes are there each second globally?
100

How high is a typical cloud?
2,000M
[6,550ft]

How many thunderstorms break out worldwide at any given moment?
2,000

How hot is the Sun? The core is around
15,000,000°C
[27,000,000°F]

We answer your burning questions about the incredible variety and awesome power of the planet's most intriguing climatic phenomena

We like to be able to control everything, but weather – those changes in the Earth's atmosphere that spell out rain, snow, wind, heat, cold and more – is one of those things that is just beyond our power. Maybe that's why a cloudless sunny day or a spectacular display of lightning both have the ability to delight us. Meteorologists have come a long way in their capability to predict weather patterns, track changes and forecast what we can expect to see when we leave our homes each day. But they're not always right. It's not their fault; we still don't completely understand all of the processes that contribute to changes in the weather.

Here's what we do know: all weather starts with contrasts in air temperature and moisture in the atmosphere. Seems simple, right? Not exactly. Temperature and moisture vary greatly depending on a huge number of factors, like the Earth's rotation, where you're located, the angle at which the Sun is hitting it at any given time, your elevation, and your proximity to the ocean. These all lead to changes in atmospheric pressure. The atmosphere is chaotic, meaning that a very small, local change can have a far-reaching effect on much larger weather systems. That's why it's especially tough to make accurate forecasts more than a few days in advance.

Is there a way to tell how close a storm is?

Lightning and thunder always go together, because thunder is the sound that results from lightning. Lightning bolts are close to 30,000 degrees Celsius (54,000 degrees Fahrenheit), so the air in the atmosphere that they zip through becomes superheated and quickly expands. That sound of expansion is called thunder, and on average it's about 120 decibels (a chainsaw is 125, for reference). Sometimes you can see lightning but not hear the thunder, but that's only because the lightning is too far away for you to hear it. Because light travels faster than sound, you always see lightning before hearing it.

1. Start the count

When you see a flash of lightning, start counting. A stopwatch would be the most accurate way.

2. Five seconds

The rule is that for every five seconds, the storm is roughly 1.6 kilometres (one mile) away.

3. Do the maths

Stop counting after the thunder and do the maths. If the storm's close, take the necessary precautions.

What is the fastest wind ever recorded, not in a tornado?

407km/h (253mph)

Gusts recorded during Cyclone Olivia in 1996

Lightning occurs most often in hot, summer-like climates

Where are you most likely to get hit by lightning?

Generally lightning strikes occur most often during the summer. So the place where lightning strikes occur the most is a place where summer-like weather prevails year-round: Africa. Specifically, it's the village of Kifuka in the Democratic Republic of Congo. Each year, it gets more than 150 lightning strikes within one square kilometre. Roy Sullivan didn't live in Kifuka but he still managed to get struck by lightning seven separate times while working as a park ranger in the Shenandoah National Park in the USA. The state in which he lived – Virginia – does have a high incidence of lightning strikes per year, but since Sullivan spent his job outdoors in the mountains, his risk was greater due to his exposure.

Is it possible to stop a hurricane?

We can't control the weather… or can we? Some scientists are trying to influence the weather through cloud seeding, or altering the clouds' processes by introducing chemicals like solid carbon dioxide (aka dry ice), calcium chloride and silver iodide. It has been used to induce rainfall during times of drought as well as to prevent storms.

CAN IT REALLY RAIN ANIMALS?

Animals have fallen from the sky before, but it's not actually 'raining' them. More likely strong winds have picked up large numbers of critters from ponds or other concentrations – perhaps from tornadoes or downspouts – then moved and deposited them. Usually the animals in question are small and live in or around water for a reason.

DOES FREAK WEATHER CONFUSE WILDLIFE?

A short period of unseasonable weather isn't confusing, but a longer one can be. For example, warm weather in winter may make plants bloom too early or animals begin mating long before spring actually rolls around.

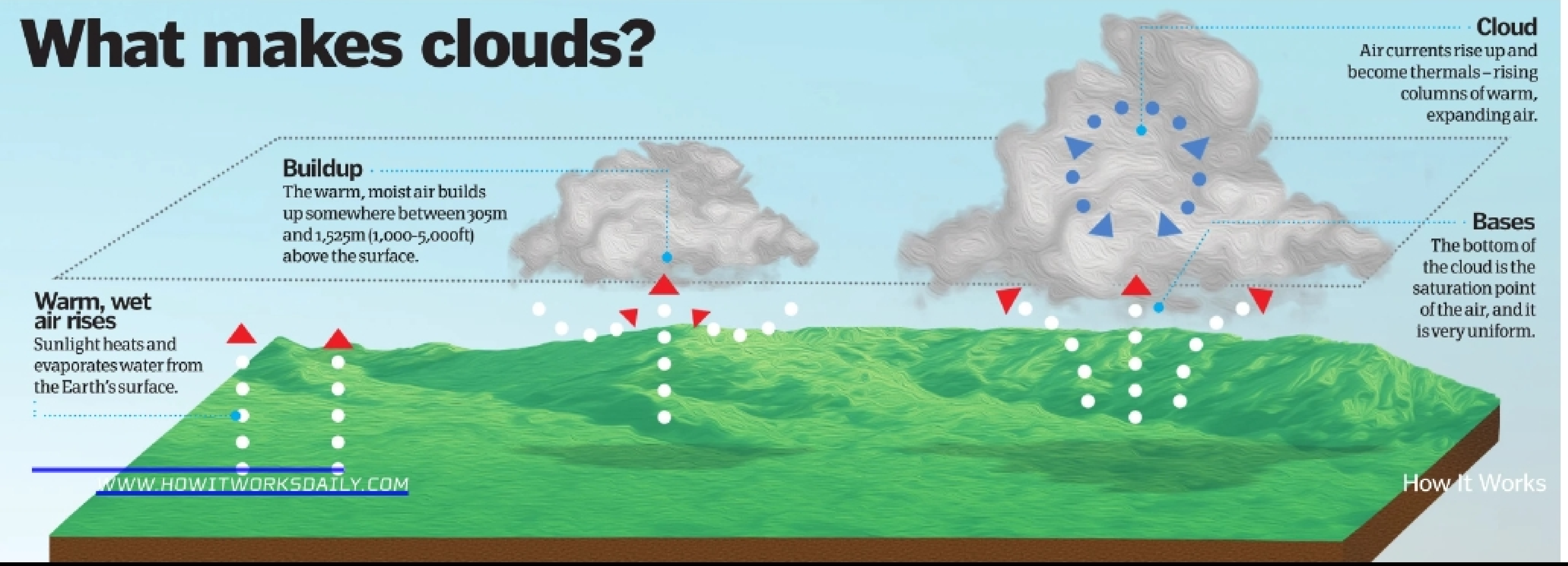
IS THE 'RED SKY AT NIGHT, SHEPHERD'S DELIGHT' SAYING TRUE?

The rest of the proverb is, 'Red sky at morning, shepherd's warning'. A red sky means you could see the red wavelength of sunlight reflecting off clouds. At sunrise, it was supposed to mean the clouds were coming towards you so rain might be on the way. If you saw these clouds at sunset, the risk had already passed. Which is 'good' or 'bad' is a matter of opinion.

WHAT ARE SNOW DOUGHNUTS?

Snow doughnuts, or rollers, are a rare natural phenomenon. If snow falls in a clump, gravity can pull it down over itself as it rolls. Normally it would collapse, but sometimes a hole forms. Wind and temperature also play key roles.

What makes clouds?



Cloud
Air currents rise up and become thermals – rising columns of warm, expanding air.

Buildup
The warm, moist air builds up somewhere between 305m and 1,525m (1,000-5,000ft) above the surface.

Bases
The bottom of the cloud is the saturation point of the air, and it is very uniform.

Warm, wet air rises
Sunlight heats and evaporates water from the Earth's surface.

WHAT ARE KATABATIC WINDS?

From the Greek for 'going downhill', a katabatic wind is also known as a drainage wind. It carries dense air down from high elevations, such as mountain tops, down a slope thanks to gravity. This is a common occurrence in places like Antarctica's Polar Plateau, where incredibly cold air on top of the plateau sinks and flows down through the rugged landscape, picking up speed as it goes. The opposite of katabatic winds are called anabatic, which are winds that blow *up* a steep slope.

DOES IT EVER SNOW IN AFRICA?

Several countries in Africa see snow – indeed, there are ski resorts in Morocco and regular snowfall in Tunisia. Algeria and South Africa also experience snowfall on occasion. It once snowed in the Sahara, but it was gone within 30 minutes. There's even snowfall around the equator if you count the snow-topped peaks of mountains.

WHAT COLOUR IS LIGHTNING?

Usually lightning is white, but it can be every colour of the rainbow. There are a lot of factors that go into what shade the lightning will appear, including the amount of water vapour in the atmosphere, whether it's raining and the amount of pollution in the air. A high concentration of ozone, for example, can make lightning look blue.

WHY DO SOME CITIES HAVE THEIR OWN MICROCLIMATE?

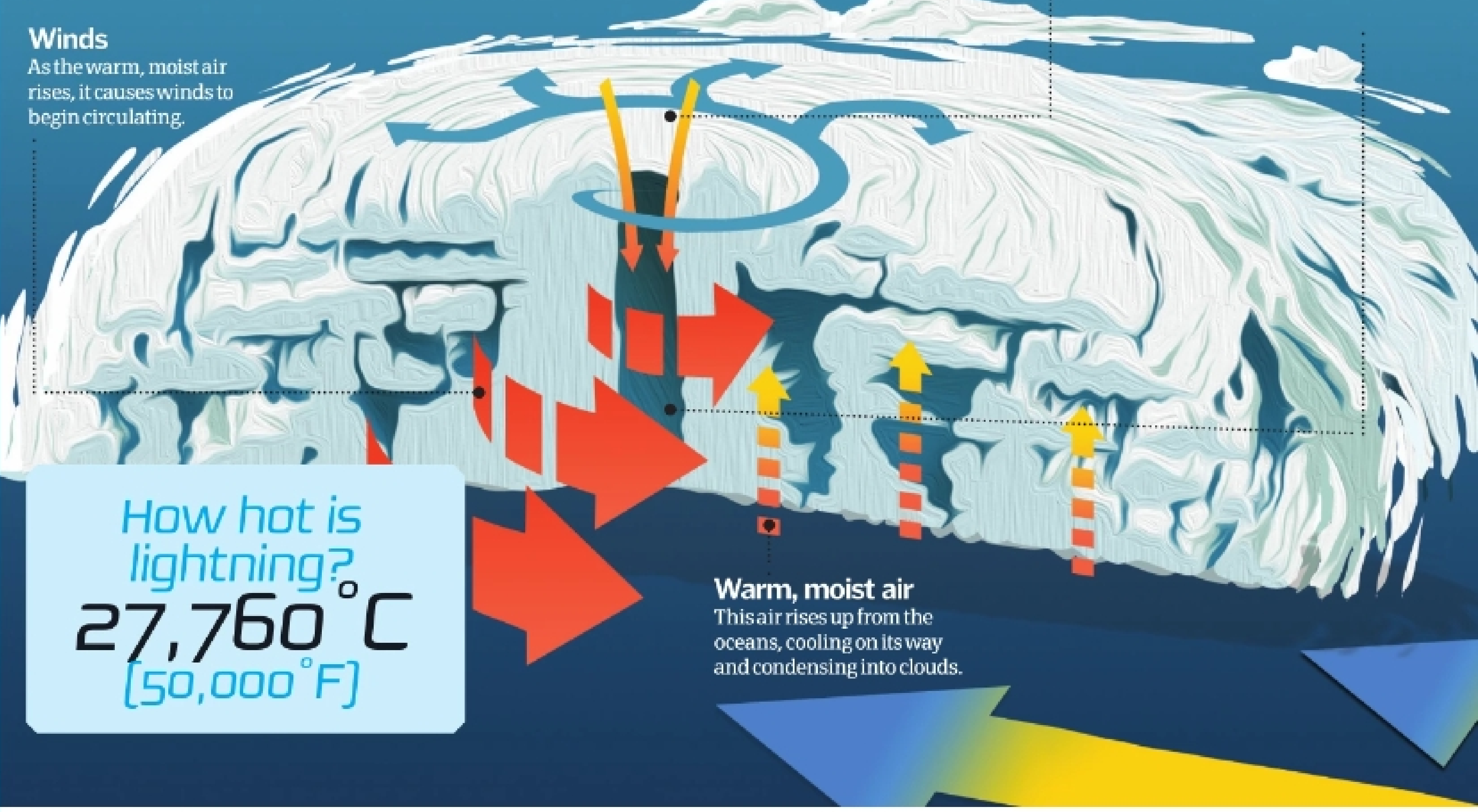
Some large metropolises have microclimates – that is, their own small climates that differ from the local environment. Often these are due to the massive amounts of concrete, asphalt and steel; these materials retain and reflect heat and do not absorb water, which keeps a city warmer at night. This phenomenon specifically is often known as an urban heat island. The extreme energy usage in large cities may also contribute to this.

What causes hurricanes?

Depending on where they start, hurricanes may also be known as tropical cyclones or typhoons. They always form over oceans around the equator, fuelled by the warm, moist air. As that air rises and forms clouds, more warm, moist air moves into the area of lower pressure below. As the cycle continues, winds begin rotating and pick up speed. Once it hits 119 kilometres (74 miles) per hour, the storm is officially a hurricane. When hurricanes reach land, they weaken and die without the warm ocean air. Unfortunately they can move far inland, bringing a vast amount of rain and destructive winds. People sometimes cite 'the butterfly effect' in relation to hurricanes. This simply means something as small as the beat of a butterfly's wing can cause big changes in the long term.

What are the odds of getting hit by lightning in a lifetime?

1 in 10,000



Cool, dry air
Cooled, dry air at the top of the system is sucked down in the centre, strengthening the winds.

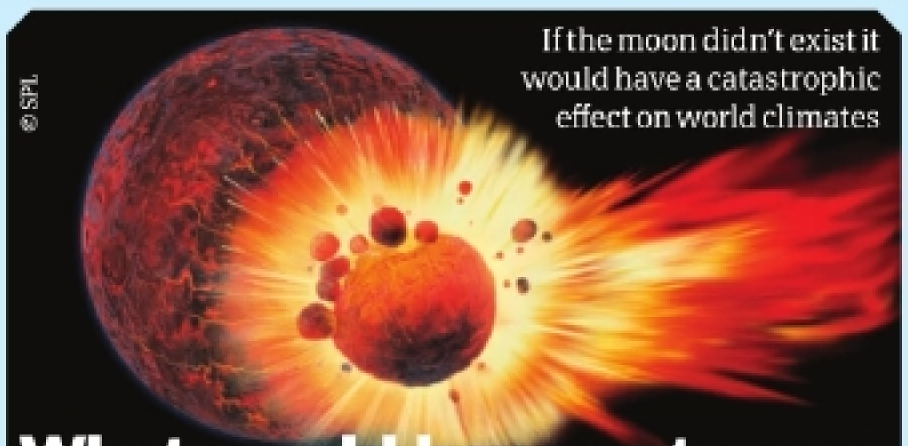
Eye
High-pressure air flows downward through this calm, low-pressure area at the heart of the storm.

Winds
As the warm, moist air rises, it causes winds to begin circulating.

Warm, moist air
This air rises up from the oceans, cooling on its way and condensing into clouds.

How hot is lightning?

27,760°C
(50,000°F)



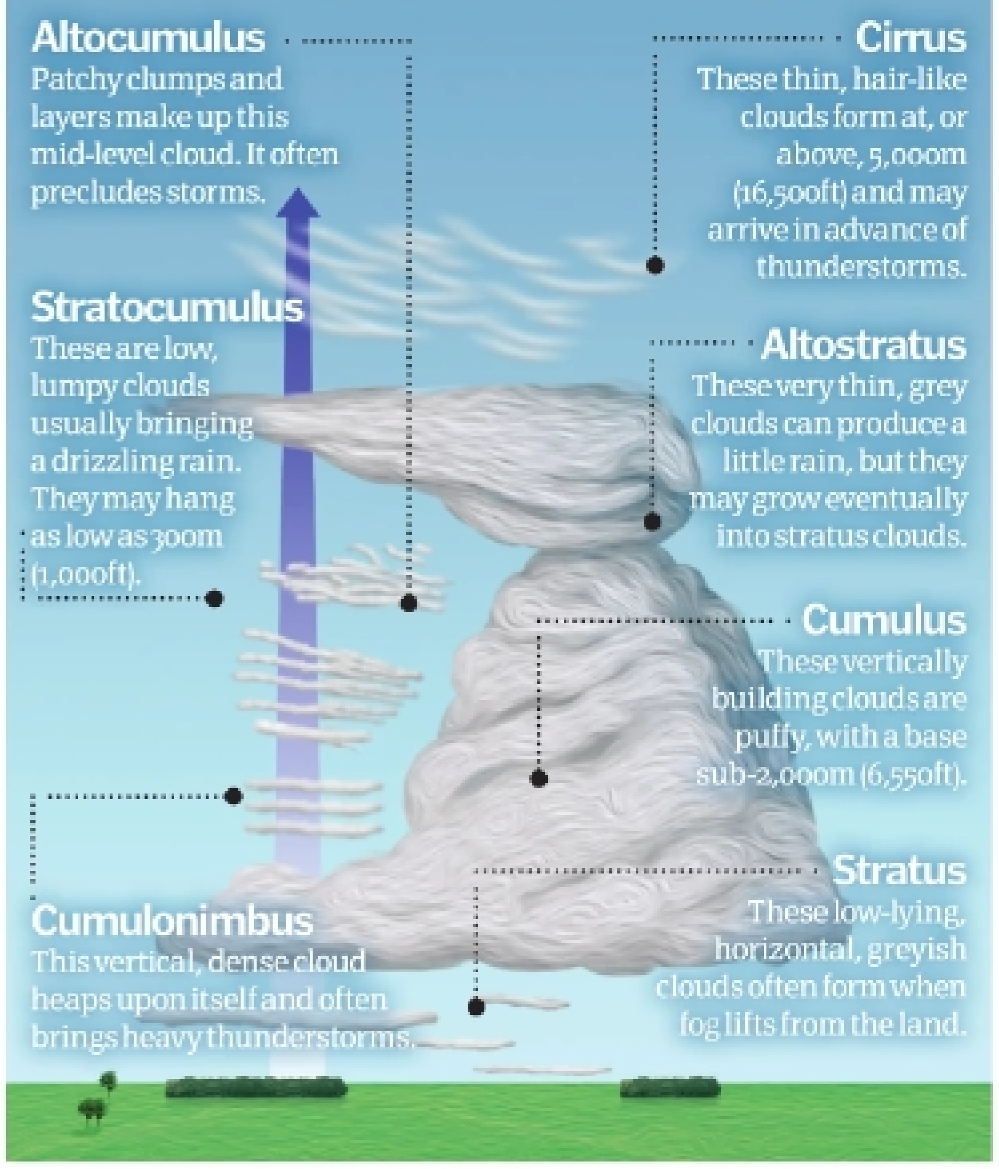
© SPL

If the moon didn't exist it would have a catastrophic effect on world climates

What would happen to our weather without the moon?

It's difficult to know exactly what would happen to our weather if the moon were destroyed, but it wouldn't be good. The moon powers Earth's tides, which in turn influence our weather systems. In addition, the loss of the moon would affect the Earth's rotation – how it spins on its axis. The presence of the moon creates a sort of drag, so its loss would probably speed up the rotation, changing the length of day and night. In addition it would alter the tilt of the Earth too, which causes the changes in our seasons. Some places would be much colder while others would become much hotter. Let's not neglect the impact of the actual destruction, either; that much debris would block out the Sun and rain down on Earth, causing massive loss of life. Huge chunks that hit the ocean could cause great tidal waves, for instance.

Why do clouds look different depending on their height?



Altocumulus
Patchy clumps and layers make up this mid-level cloud. It often precludes storms.

Stratocumulus
These are low, lumpy clouds usually bringing a drizzling rain. They may hang as low as 300m (1,000ft).

Cumulonimbus
This vertical, dense cloud heaps upon itself and often brings heavy thunderstorms.

Cirrus
These thin, hair-like clouds form at, or above, 5,000m (16,500ft) and may arrive in advance of thunderstorms.

Altostratus
These very thin, grey clouds can produce a little rain, but they may grow eventually into stratus clouds.

Cumulus
These vertically building clouds are puffy, with a base sub-2,000m (6,550ft).

Stratus
These low-lying, horizontal, greyish clouds often form when fog lifts from the land.

© SPL

How many volts are in a lightning flash?

1 billion

Why are you safer inside a car during an electrical storm?

People used to think the rubber tyres on a car grounded any lightning that may strike it and that's what kept you safe. However, you're safer in your car during an electrical storm because of the metal frame. It serves as a conductor of electricity, and channels the lightning away into the ground without impacting anything – or anyone – inside; this is known as a Faraday cage. While it is potentially dangerous to use a corded phone or other appliances during a storm because lightning can travel along cables, mobile or cordless phones are fine. It's also best to avoid metallic objects, including golf clubs.

What is ball lightning?

This mysterious phenomenon looks like a glowing ball of lightning, and floats near the ground before disappearing, often leaving a sulphur smell. Despite many sightings, we're still not sure what causes it.

© SPL

What causes giant hailstones?

Put simply, giant hailstones come from giant storms – specifically a thunderstorm called a supercell. It has a strong updraft that forces wind upwards into the clouds, which keeps ice particles suspended for a long period. Within the storm are areas called growth regions; raindrops spending a long time in these are able to grow into much bigger hailstones than normal.

WHAT IS CLOUD IRIDESCENCE?

This happens when small droplets of water or ice crystals in clouds scatter light, appearing as a rainbow of colours. It's not a common phenomenon because the cloud has to be very thin, and even then the colours are often overshadowed by the Sun.

WHAT DO WEATHER SATELLITES DO?

The GOES (Geostationary Operational Environmental Satellite) system is run by the US National Environmental Satellite, Data, and Information Service (NESDIS). The major element of GOES comprises four different geosynchronous satellites (although there are other geo-satellites either with other uses now or decommissioned).

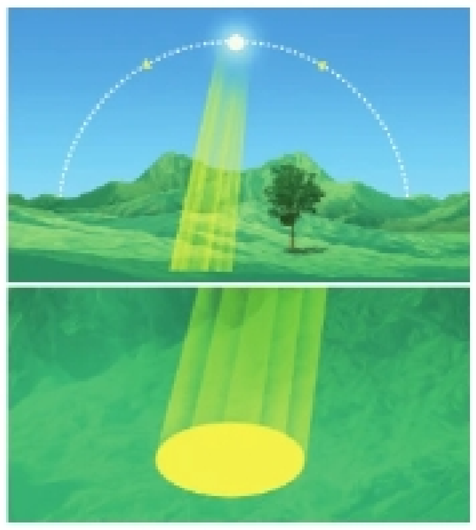
The whole system is used by NOAA's National Weather Service for forecasting, meteorological research and storm tracking. The satellites provide continuous views of Earth, giving data on air moisture, temperature and cloud cover. They also monitor solar and near-space activities like solar flares and geomagnetic storms.

How does the Sun cause the seasons?

Seasons are caused by the Earth's revolution around the Sun, as well as the tilt of the Earth on its axis. The hemisphere receiving the most direct sunlight experiences spring and summer, while the other experiences autumn and winter. During the warmer months, the Sun is higher in the sky, stays above the horizon for longer, and its rays are more direct. During the cooler half, the Sun's rays aren't as strong and it's lower in the sky. The tilt causes these dramatic differences, so while those in the northern hemisphere are wrapping up for snow, those in the southern hemisphere may be sunbathing on the beach.

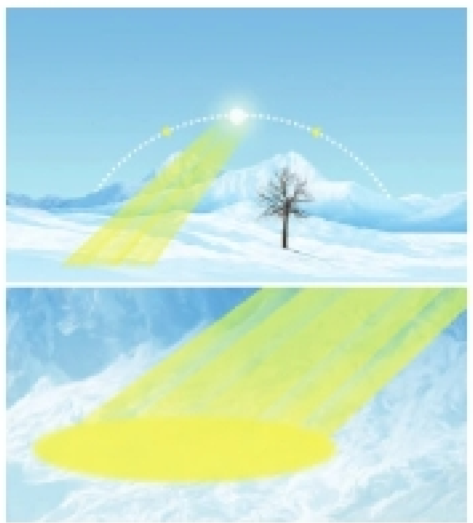
SUMMER

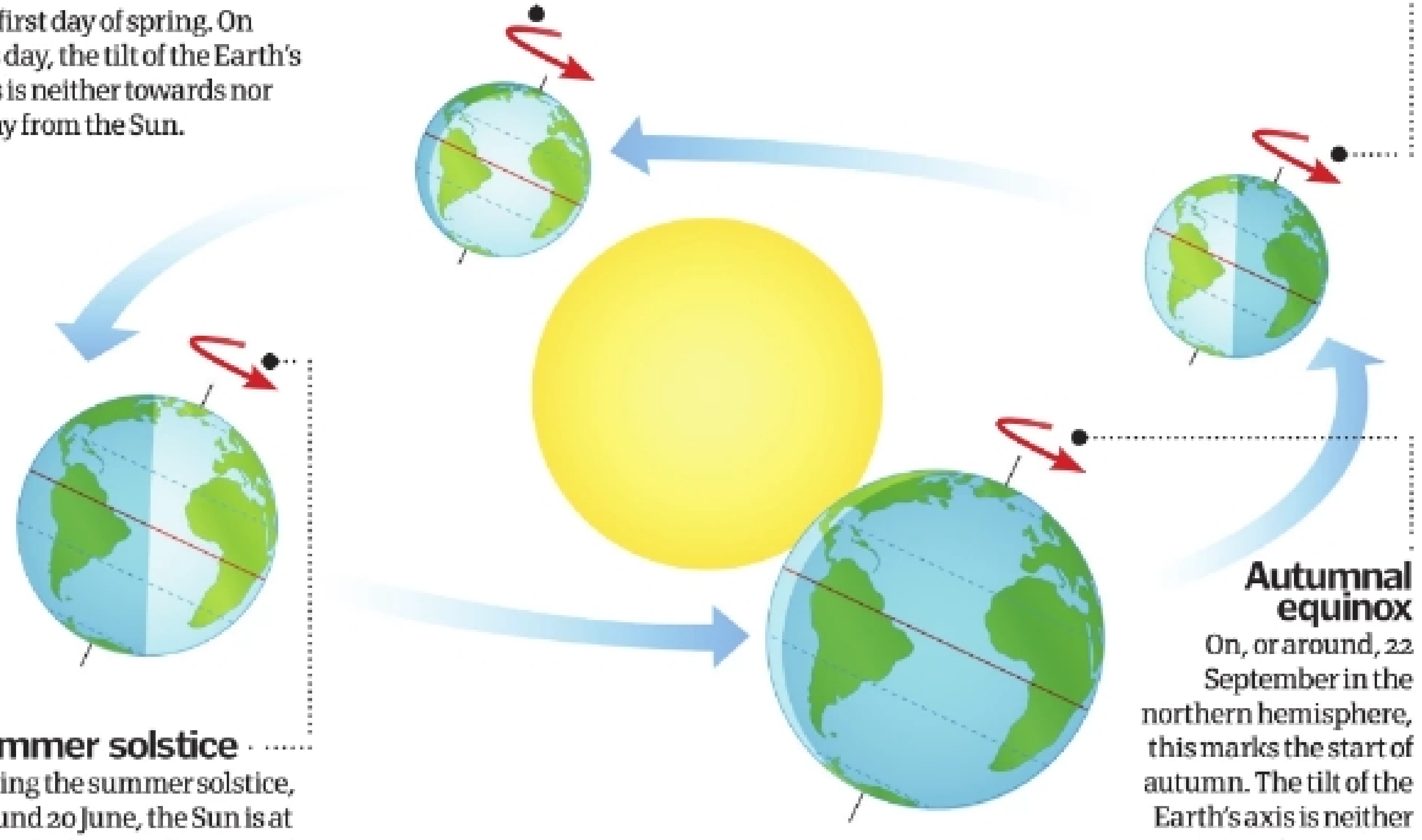
The Sun is at its highest point in the sky and takes up more of the horizon. Its rays are more direct.



WINTER

The Sun is at its lowest point in the sky and there is less daylight. The rays are also more diffuse.





Vernal equinox

For the northern hemisphere, this day – around 20 March – marks the first day of spring. On this day, the tilt of the Earth's axis is neither towards nor away from the Sun.

Winter solstice

The winter solstice marks the beginning of winter, with the Sun at its lowest point in the sky; it takes place around 20 December each year.

Summer solstice

During the summer solstice, around 20 June, the Sun is at its highest, or northernmost, point in the sky.

Autumnal equinox

On, or around, 22 September in the northern hemisphere, this marks the start of autumn. The tilt of the Earth's axis is neither towards nor away from the Sun.

HOW LONG DOES A RAINBOW LAST?

There is no set rule for the duration a rainbow will last. It all depends on how long the light is refracted by water droplets in the air (eg rain, or the spray from a waterfall).

WHY DOES IT SMELL FUNNY AFTER RAIN?

This scent comes from bacteria in the soil. Once the earth dries, the bacteria (called actinomycetes) release spores. Rainfall kicks these spores up into the air, and then the moist air disperses them. They tend to have a sweet, earthy odour.

HOW MUCH RAIN CAN A HURRICANE BRING?

The average hurricane, with a radius of about 1,330 kilometres (825 miles), can dump as much as 21.3×10^{15} cubic centimetres (1.3×10^{15} cubic inches) of water a day. That's enough rain to fill up 22 million Olympic-size swimming pools!

HOW DO DROUGHTS AND HEAT WAVES DIFFER?

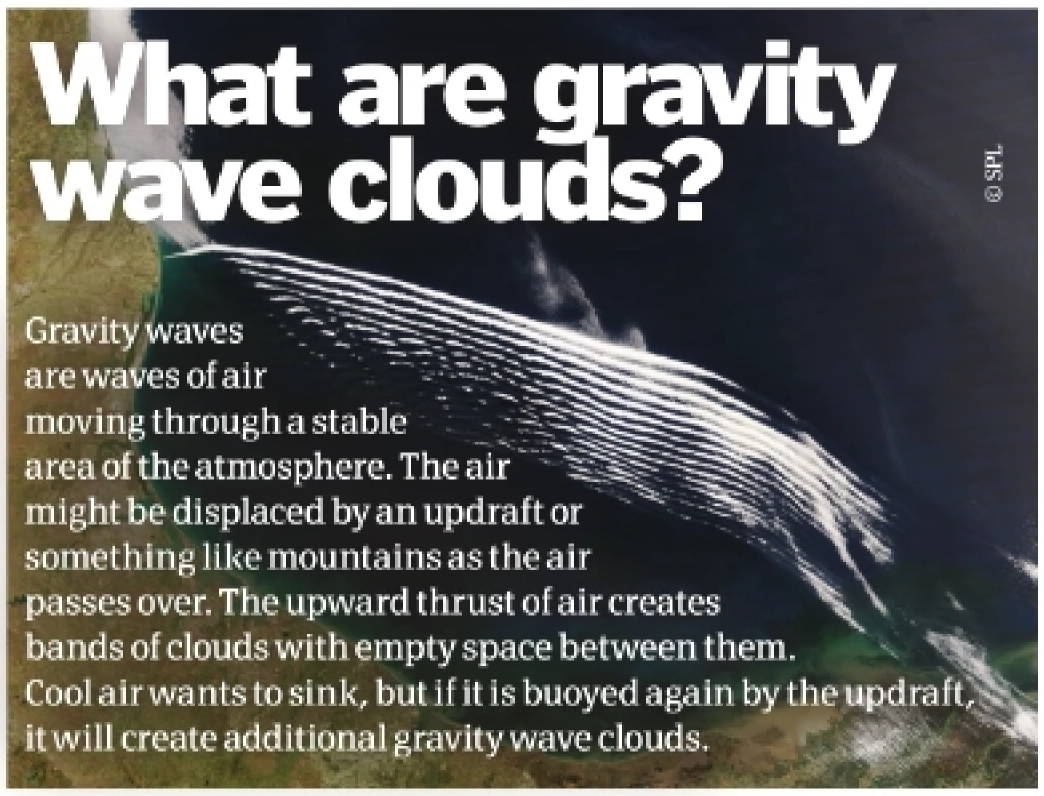
Droughts are about an extreme lack of water, usually due to lower than average rainfall, and last for months or even years. There's no set definition of a heat wave, but it typically means higher than average temperatures for several consecutive days. Both can lead to crop failures and fatalities.

WHY ARE RAINBOWS ARCH-SHAPED?

Rainbows are arched due to the way sunlight hits raindrops. It bends as it passes through because it slows during this process. Then, as the light passes out of the drop, it bends again as it returns to its normal speed.

What's the difference between rain, sleet and snow?

When it comes to precipitation, it's all about temperature. When the air is sufficiently saturated, water vapour begins to form clouds around ice, salt or other cloud seeds. If saturation continues, water droplets grow and merge until they become heavy enough to fall as rain. Snow forms when the air is cold enough to freeze supercooled water droplets – lower than -31 degrees Celsius (-34 degrees Fahrenheit) – then falls. Sleet is somewhere in between: it starts as snow but passes through a layer of warmer air before hitting the ground, resulting in some snow melting.

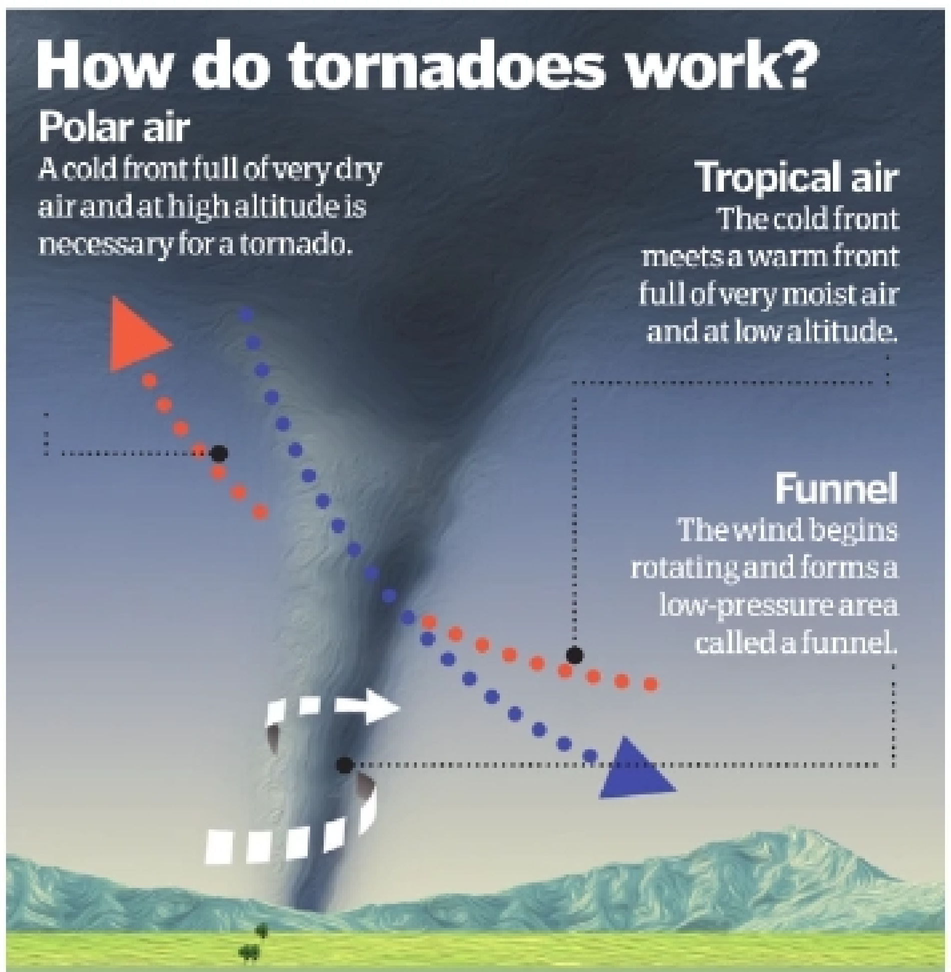


What are gravity wave clouds?

© SPL

Gravity waves are waves of air moving through a stable area of the atmosphere. The air might be displaced by an updraft or something like mountains as the air passes over. The upward thrust of air creates bands of clouds with empty space between them. Cool air wants to sink, but if it is buoyed again by the updraft, it will create additional gravity wave clouds.

How do tornadoes work?



Polar air
A cold front full of very dry air and at high altitude is necessary for a tornado.

Tropical air
The cold front meets a warm front full of very moist air and at low altitude.

Funnel
The wind begins rotating and forms a low-pressure area called a funnel.

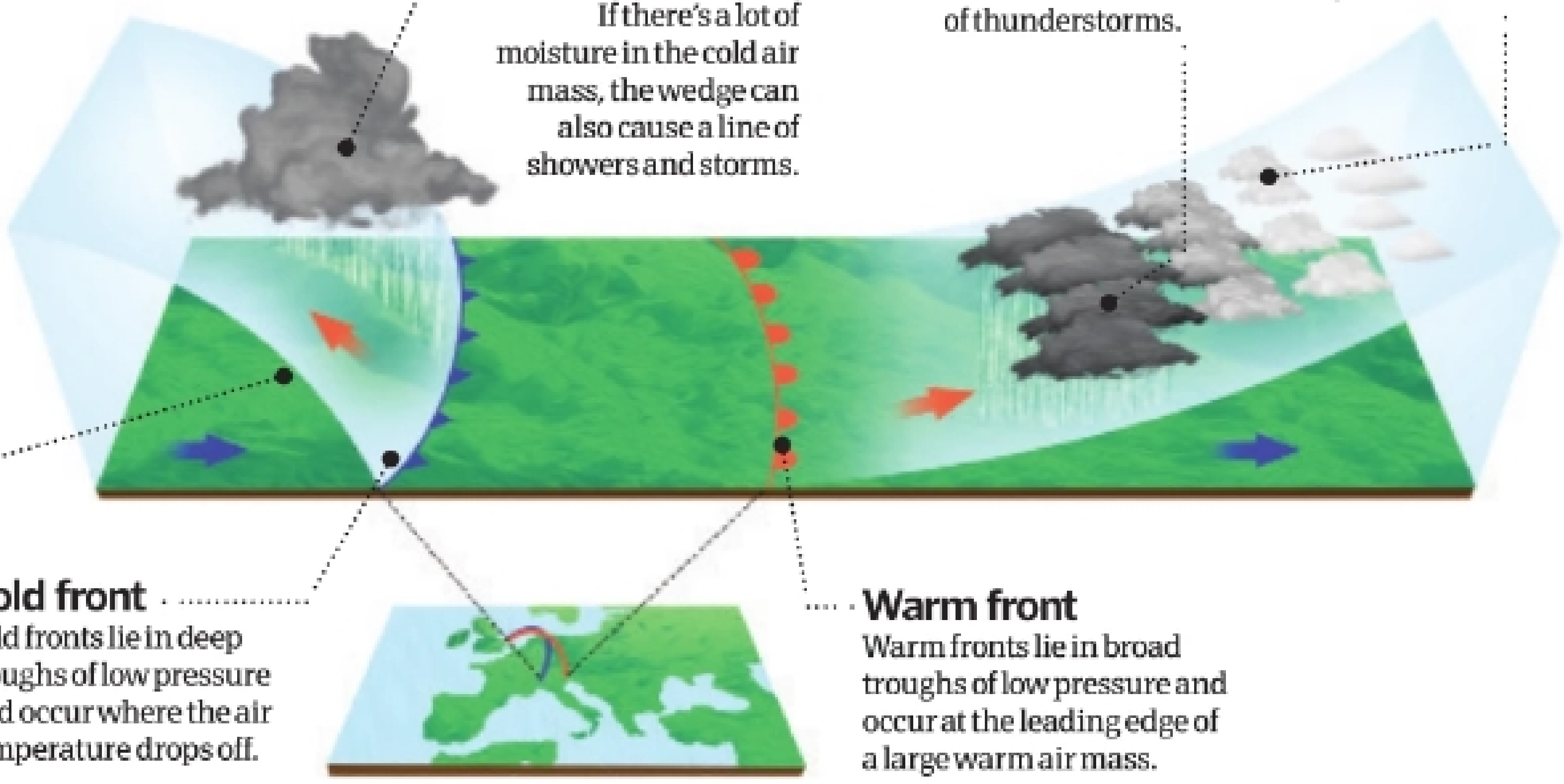
Tornadoes start out with severe thunderstorms called supercells. They form when polar air comes in contact with tropical air in a very unstable atmosphere. Supercells contain a rotating updraft of air that is known as a mesocyclone, which keeps them going for a long time. High winds add to the rotation, which keeps getting faster and faster until eventually it forms a funnel. The funnel cloud creates a sucking area of low pressure at the bottom. As soon as this funnel comes in to contact with the Earth, you have a tornado.

Why is it so quiet after it snows?

It's peaceful after snowfall as the snow has a dampening effect; pockets of air between the flakes absorb noise. However, if it's compacted snow and windy, the snow might actually reflect sound.

What is a weather front?

A weather front is the separation between two different masses of air, which have differing densities, temperature and humidity. On weather maps, they're delineated by lines and symbols. The meeting of different frontal systems causes the vast majority of weather phenomena.



Wet 'n' wild
If there's a lot of moisture in the cold air mass, the wedge can also cause a line of showers and storms.

Thunderstorms
Unstable masses of warm air often contain stratiform clouds, full of thunderstorms.

Fog
Fog often comes before the slow-moving warm front.

Wedge
As cold air is denser, it often 'wedges' beneath the warm air. This lift can cause wind gusts.

Cold front
Cold fronts lie in deep troughs of low pressure and occur where the air temperature drops off.

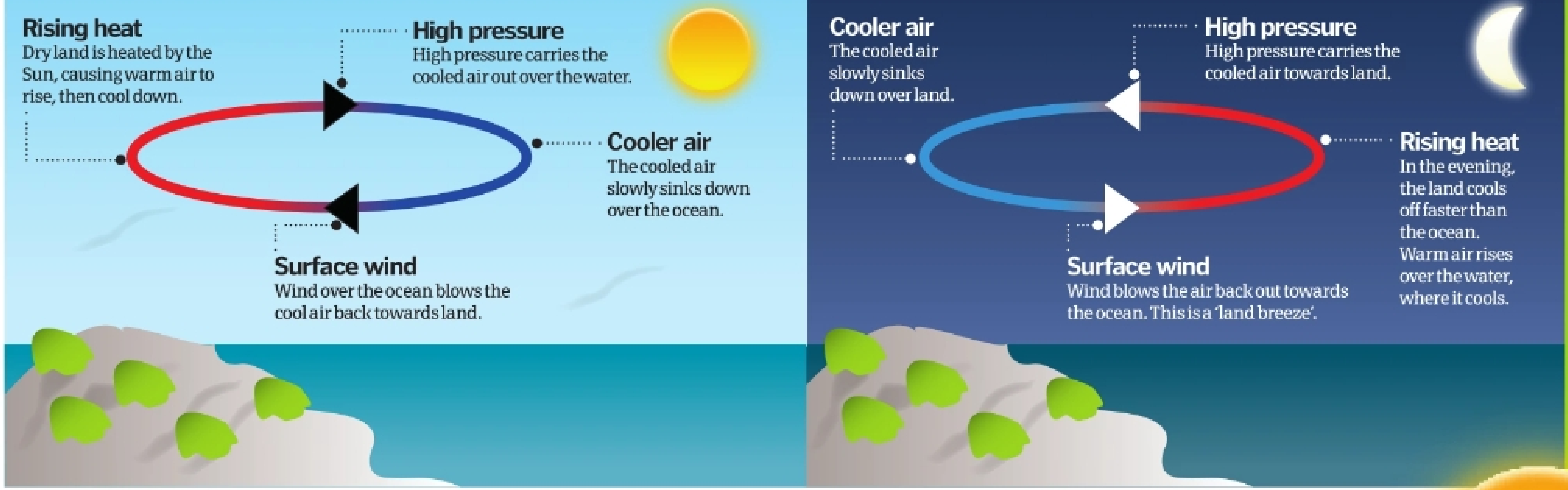
Warm front
Warm fronts lie in broad troughs of low pressure and occur at the leading edge of a large warm air mass.

How hot was the hottest day in history?

58°C (136°F)

Recorded on 13 September 1922 in Al Aziziyah, Libya

What is a sea breeze?



Rising heat
Dry land is heated by the Sun, causing warm air to rise, then cool down.

High pressure
High pressure carries the cooled air out over the water.

Cooler air
The cooled air slowly sinks down over the ocean.

Surface wind
Wind over the ocean blows the cool air back towards land.

Cooler air
The cooled air slowly sinks down over land.

High pressure
High pressure carries the cooled air towards land.

Rising heat
In the evening, the land cools off faster than the ocean. Warm air rises over the water, where it cools.

Surface wind
Wind blows the air back out towards the ocean. This is a 'land breeze'.

What is the eye of a storm?

The eye is the calm centre of a storm like a hurricane or tornado, without any weather phenomena. Because these systems consist of circular, rotating winds, air is funnelled downward through the eye and feeds back into the storm itself.

The eye at the centre of a hurricane tends to be 20-50km (12-31mi) in diameter

© NASA

What are red sprites and blue jets?

© SPL

These are both atmospheric and electrical phenomena that take place in the upper atmosphere, and are also known as upper-atmosphere discharge. They take place above normal lightning; blue jets occur around 40-50 kilometres (25-30 miles) above the Earth, while red sprites are higher at 50-100 kilometres (32-64 miles). Blue jets happen in cone shapes above thunderstorm clouds, and are not related to lightning. They're blue due to ionised emissions from nitrogen. Red sprites can appear as different shapes and have hanging tendrils. They occur when positive lightning goes from the cloud to the ground.

Does lightning ever strike in the same place twice?

Yes, lightning often strikes twice in the same location. If there's a thunderstorm and lightning strikes, it's just as likely to happen again. Many tall structures get struck repeatedly during thunderstorms, such as New York City's famed Empire State Building or NASA's shuttle launch pad in Cape Canaveral, Florida.

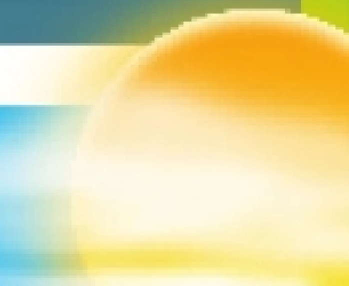
How cold was the coldest day in history?

-89°C (-129°F)

Recorded on 21 July 1983 at Vostok II Station, Antarctica

Why does the Sun shine?

The Sun is a super-dense ball of gas, where hydrogen is continually burned into helium (nuclear fusion). This generates a huge deal of energy, and the core reaches 15 million degrees Celsius (27 million degrees Fahrenheit). This extreme heat produces lots of light.



WHY ARE CLOUDS FLUFFY?

Fluffy-looking clouds – the big cotton-ball ones – are a type called cumulus. They form when warm air rises from the ground, meets a layer of cool air and moisture condenses. If the cloud grows enough to meet an upper layer of freezing air, rain or snow may fall from the cloud.

WHAT'S IN ACID RAIN?

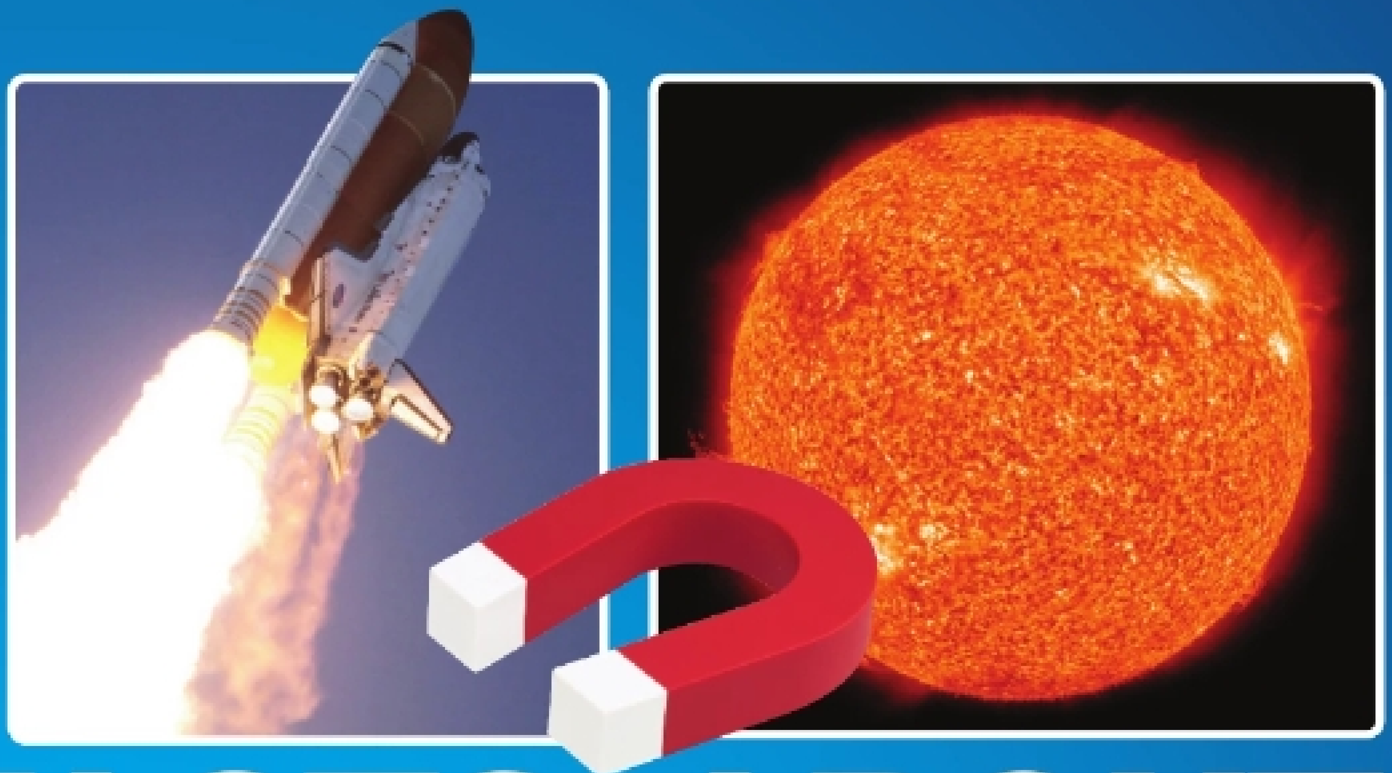
Acid rain is full of chemicals like nitrogen oxide, carbon dioxide and sulphur dioxide, which react with water in the rain. Much of it comes from coal powerplants, cars and factories. It can harm wildlife and also damage buildings.

WHY CAN I SEE MY BREATH IF IT'S COLD?

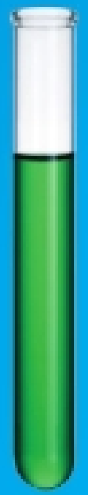
Your breath is full of warm water vapour because your lungs are moist. When it's cold outside and you breathe out, that warm vapour cools rapidly as it hits the cold air. The water molecules slow down, begin to change form, and bunch up together, becoming visible.

WHAT IS THE GREEN FLASH YOU SEE AS THE SUN SETS SOMETIMES?

At sunsets (or indeed rises), the Sun can occasionally change colour due to refraction. This can cause a phenomenon called green flash. It only lasts for a second or two so can be very tricky to spot.



50 AMAZING FACTS ABOUT SCIENCE



From Earth's geology to the complex workings of the human body and on to the farthest reaches of outer space, HIW presents some fascinating insights that will blow your mind

Like you, we love learning about science. And luckily, every day is a school day on **How It Works** magazine because there's *always* something new and remarkable to discover about the world we live in. From the very moment we're born we begin to take in information about the planet around us, and as we get older it becomes only natural to grow curious and start asking questions like how and why.

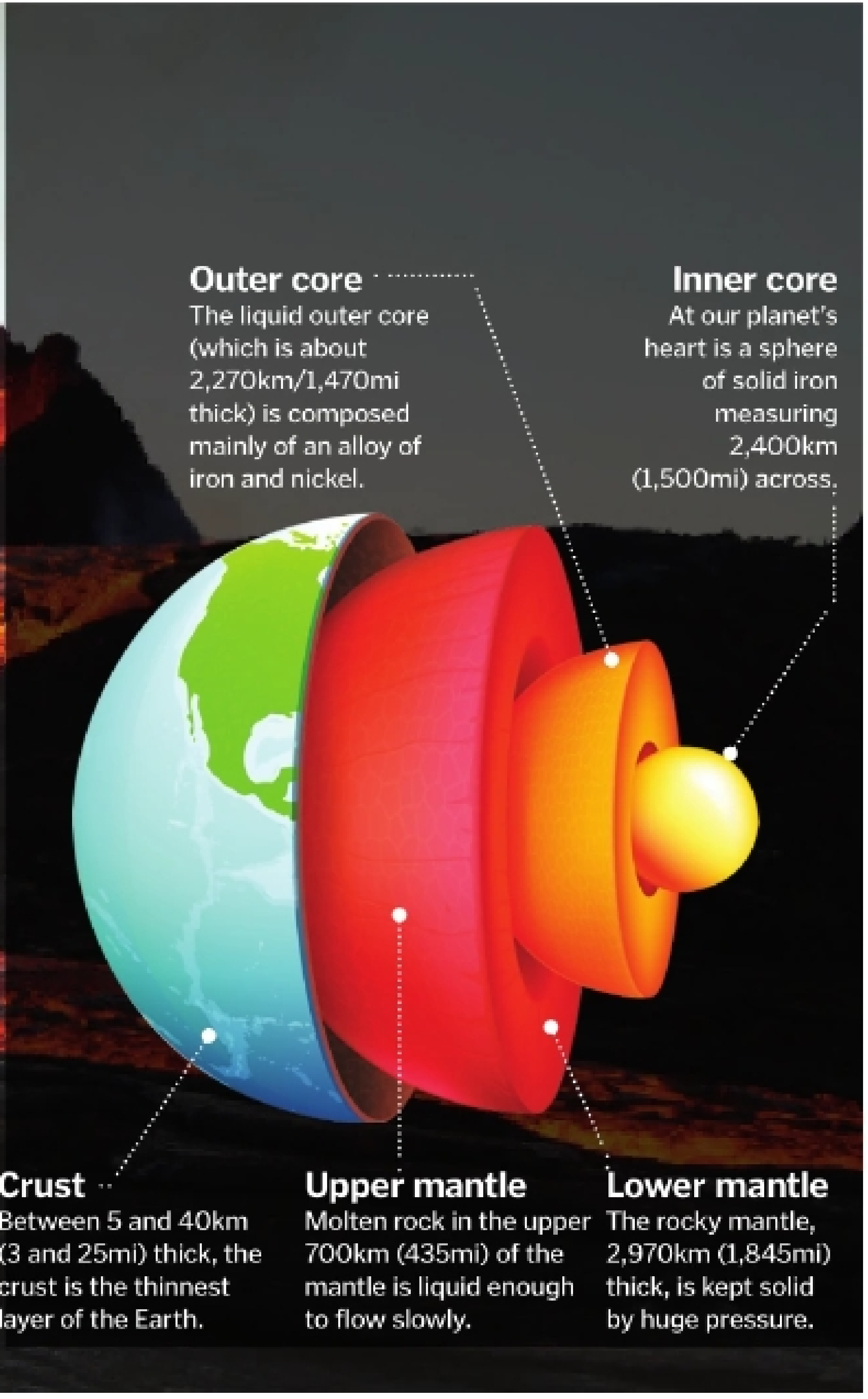
So not only does this special **How It Works** feature reveal 50 of the most amazing science facts, but it also explains the equally amazing principles that lie behind them, helping you to get a handle on *why* each fact works the way it does.

When we announced on Twitter we were running a feature about incredible scientific trivia, our feed was immediately inundated by readers keen to share their favourite nuggets of information. And after sifting through the hundreds of fantastic entries that came in from all over the world – and doing some of our own research – we selected the best of the bunch.

Topics cover everything from the origins of the cosmos to how the cells in our bodies work, so over these eight jam-packed pages, you will discover a wealth of mindblowing knowledge to astound you and everyone you know as we explain the science behind some of the universe's most amazing facts. ✽

1. 84% of the Earth's volume is molten rock

Most of the Earth's volume is contained in the mantle, a rocky layer 2,970 kilometres (1,845 miles) thick, sandwiched between the planet's core and crust. Despite temperatures approaching 4,300 degrees Celsius (7,772 degrees Fahrenheit) near the core, most of the mantle is solid due to the huge pressure it is under. Earthquakes are an important source of information about what lies beneath our feet. By studying how seismological waves spread through the planet, geologists can deduce its structure. Certain waves, for example, can't travel through liquids, leading scientists to conclude that the planet's outer core is liquid.



Outer core
The liquid outer core (which is about 2,270km/1,470mi thick) is composed mainly of an alloy of iron and nickel.

Inner core
At our planet's heart is a sphere of solid iron measuring 2,400km (1,500mi) across.

Crust
Between 5 and 40km (3 and 25mi) thick, the crust is the thinnest layer of the Earth.

Upper mantle
Molten rock in the upper 700km (435mi) of the mantle is liquid enough to flow slowly.

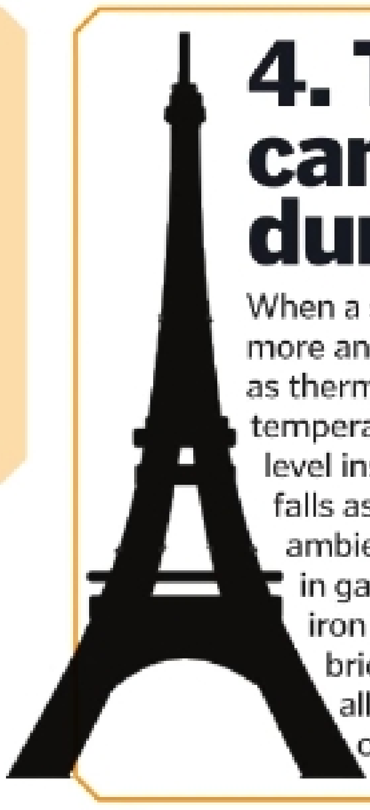
Lower mantle
The rocky mantle, 2,970km (1,845mi) thick, is kept solid by huge pressure.

2. You can't see a laser beam in space

A laser is a highly focused beam of light. So focused, in fact, that none of its photons deviate from their path and enter your eyes, unless they are reflected by particles of dust. In the almost-perfect vacuum of space there is no matter so lasers are invisible, despite what many a science-fiction film might suggest.

3. Babies have around 100 more bones than adults

Babies have about 300 bones at birth, with cartilage between many of them. This extra flexibility helps them pass through the birth canal and also allows for rapid growth. With age, many of the bones fuse, leaving 206 bones that make up an average adult skeleton.



4. The Eiffel Tower can be 15cm taller during the summer

When a substance is heated up, its particles move more and it takes up a larger volume – this is known as thermal expansion. Conversely, a drop in temperature causes it to contract again. The mercury level inside a thermometer, for example, rises and falls as the mercury's volume changes with the ambient temperature. This effect is most dramatic in gases but occurs in liquids and solids such as iron too. For this reason large structures such as bridges are built with expansion joints which allow them some leeway to expand and contract without causing any damage.

5. Butterflies taste with their feet

Butterflies' hind feet, technically known as tarsi, are covered in chemoreceptors – tiny organs which allow them to taste something just by standing on it. This anatomical quirk enables a female butterfly to pick a leaf suitable for her caterpillars to eat before she lays her eggs. More generally, once it has spotted a tasty-looking flower, a butterfly can sample the goods quickly before settling down to feed.

6 Muscles can remember

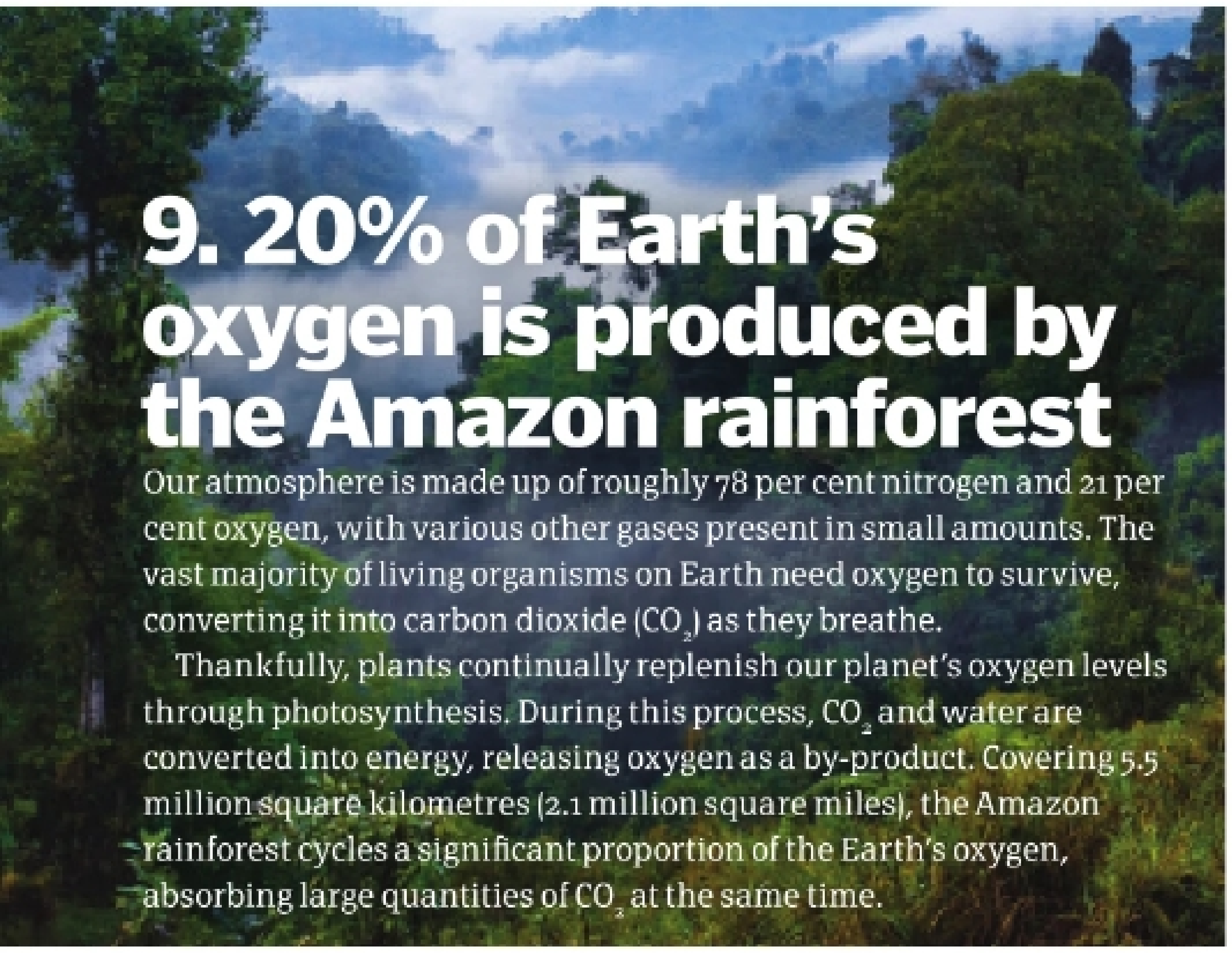
The first time you perform an action – tying shoelaces, for example, it feels awkward, but with enough repetition it becomes second nature. The brain stores sets of motor instructions, allowing such tasks to be executed without conscious effort. Muscle memory is retained for a long time, so skills like driving a car are rarely completely lost.

7 Pumice is the only rock that can float

Pumice is formed when hot, highly pressurised lava is ejected from a volcano. The sudden drop in pressure and rapid cooling trap bubbles of gas in the rock, giving it a lower density than water.

8 Only diamond can cut diamond

Diamonds are carbon, with each atom bound with strong covalent bonds to four neighbours in a rigid lattice. Diamonds tend to grow in octahedral shapes, and some of the octahedron's faces are weaker than others. Jewellers can cut along these planes with special tools coated in diamond dust.



9. 20% of Earth's oxygen is produced by the Amazon rainforest

Our atmosphere is made up of roughly 78 per cent nitrogen and 21 per cent oxygen, with various other gases present in small amounts. The vast majority of living organisms on Earth need oxygen to survive, converting it into carbon dioxide (CO_2) as they breathe.

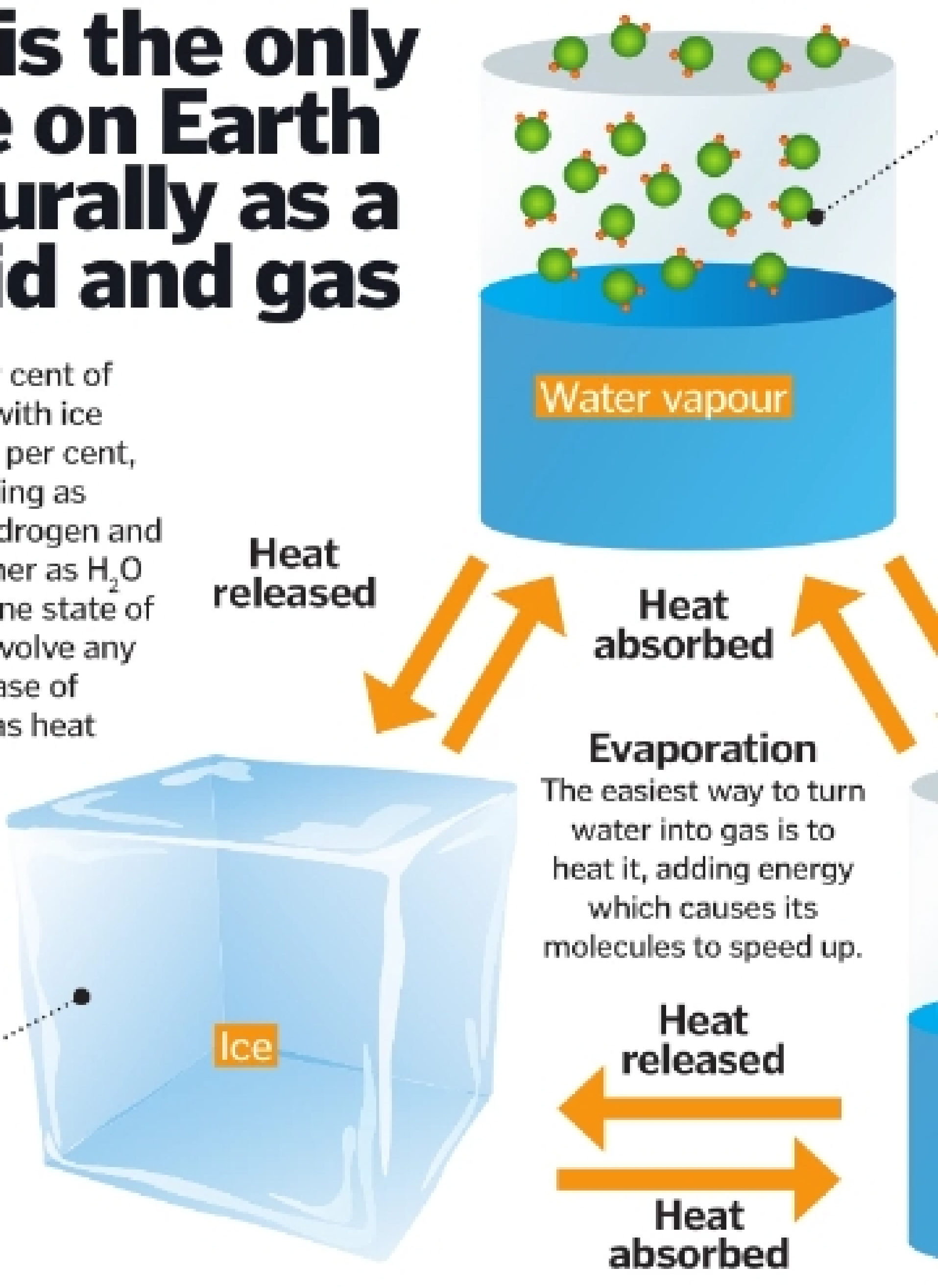
Thankfully, plants continually replenish our planet's oxygen levels through photosynthesis. During this process, CO_2 and water are converted into energy, releasing oxygen as a by-product. Covering 5.5 million square kilometres (2.1 million square miles), the Amazon rainforest cycles a significant proportion of the Earth's oxygen, absorbing large quantities of CO_2 at the same time.

10. Dynamite may contain nuts

Dynamite's explosive ingredient is nitroglycerin, absorbed onto clay particles for stability. Nitroglycerin is made with glycerol, which can be extracted from peanuts. This said, there are other ways of producing nitroglycerin as well.

13. Water is the only substance on Earth found naturally as a solid, liquid and gas

At any one time, over 98 per cent of our planet's water is liquid, with ice making up a little under two per cent, and only a tiny fraction existing as vapour. Water is made of hydrogen and oxygen atoms, bound together as H_2O molecules. Changing from one state of matter to another doesn't involve any chemical changes but is a case of adding or removing energy as heat or pressure, affecting the behaviour of the H_2O. In liquid water, molecules move freely. Cool it down and, as they lose energy, the molecules slow down until the point where they form a rigid structure: ice.



Evaporation
The easiest way to turn water into gas is to heat it, adding energy which causes its molecules to speed up.

Solid
In ice, the H_2O molecules have very little energy and lock into a rigid lattice.

11. The brain does not feel pain

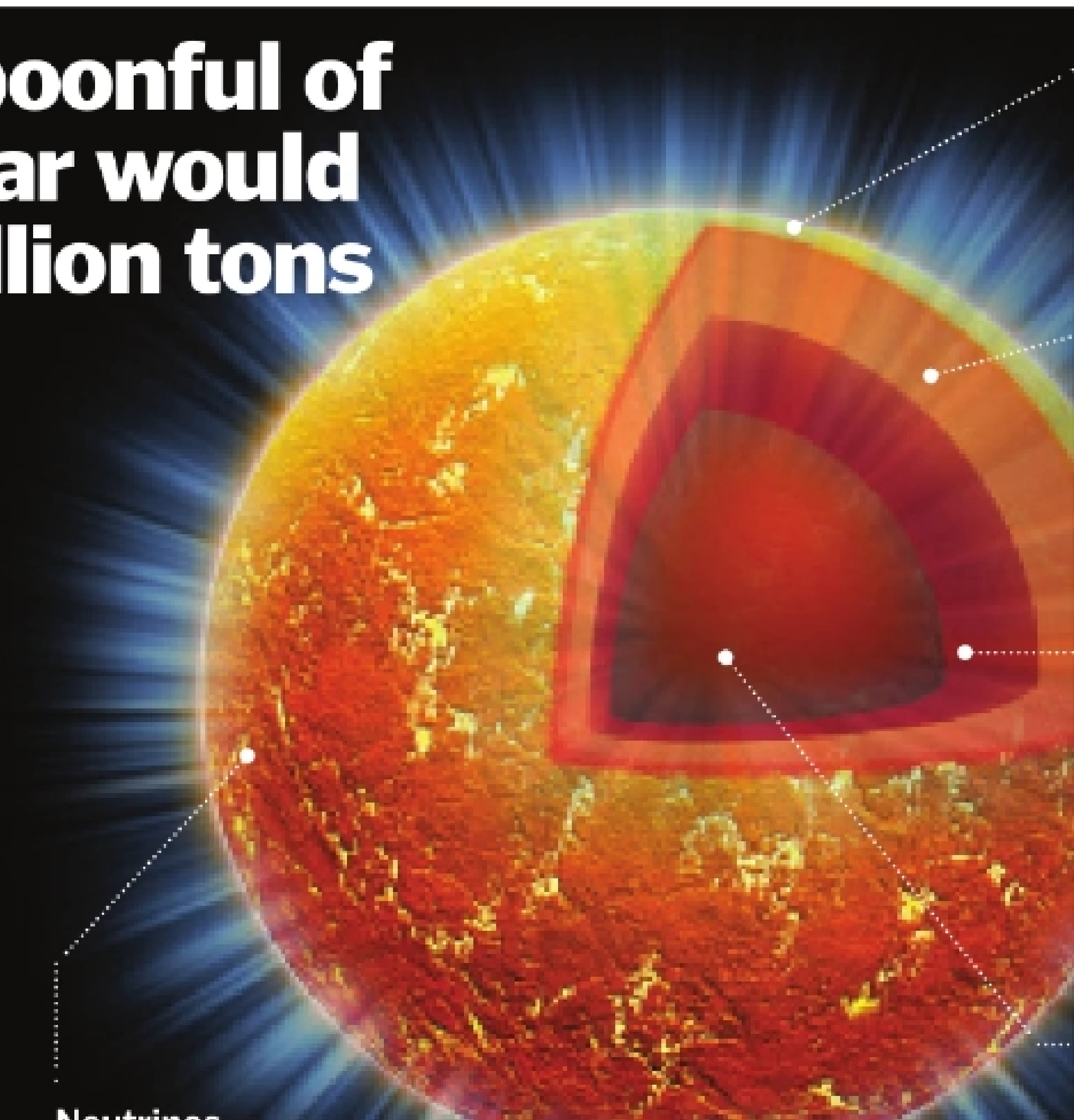
We feel pain thanks to nociceptors – sensory receptors which send signals to the spinal cord and brain, alerting us to danger and enabling us to react. Nociceptors are found throughout the body, particularly just under the skin, but they are entirely absent from one place: the brain. When you have a headache, it isn't actually your brain that's suffering but the tissues around it which include muscles, sinuses and the membranes that protect the organ.

12. Some metals are so reactive that they explode on contact with water

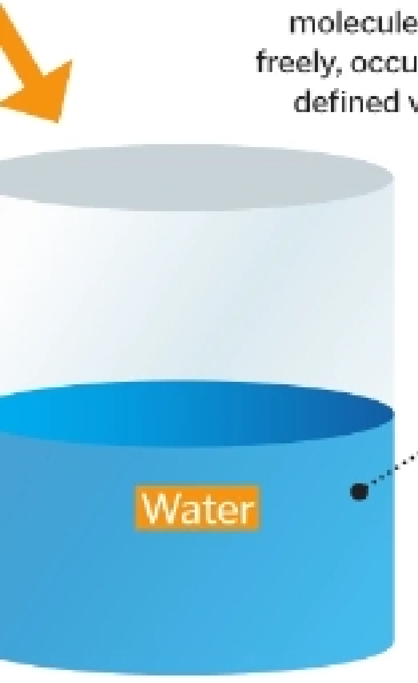
There are certain metals – including potassium, sodium, lithium, rubidium and caesium – that are so reactive that they oxidise (or tarnish) instantly when exposed to air. They can even produce explosions when dropped in water! All elements strive to be chemically stable – in other words, to have a full outer electron shell. To achieve this, metals tend to shed electrons. The alkali metals have only one electron on their outer shell, making them ultra-keen to pass on this unwanted passenger to another element via bonding. As a result they form compounds with other elements so readily that they don't exist independently in nature.

14. A teaspoonful of neutron star would weigh 6 billion tons

A neutron star is the remnants of a massive star that has run out of fuel. The dying star explodes in a supernova while its core collapses in on itself due to gravity, forming a super-dense neutron star. Astronomers measure the mind-bogglingly large masses of stars or galaxies in solar masses, with one solar mass equal to the Sun's mass (that is, 2×10^{30} kilograms/4.4×10^{30} pounds). Typical neutron stars have a mass of up to three solar masses, which is crammed into a sphere with a radius of approximately ten kilometres (6.2 miles) – resulting in some of the densest matter in the known universe.



Neutrinos
Neutrinos produced by superfluid in the inner core escape, allowing the star to cool as it loses energy.



Gas
Water vapour molecules possess lots of energy, bouncing off one another and increasing the gas's volume.

Condensation
Cooling water vapour down releases energy, allowing the water molecules to slow down and form a liquid.

Heat released

Liquid
As a liquid, H_2O molecules move freely, occupying a defined volume.

Outer crust
The rigid crust is made up of a lattice of iron nuclei, which are bathed in electrons.

Inner crust
The crushing pressure forces protons and electrons together, forming neutrons which leak out of the nuclei.

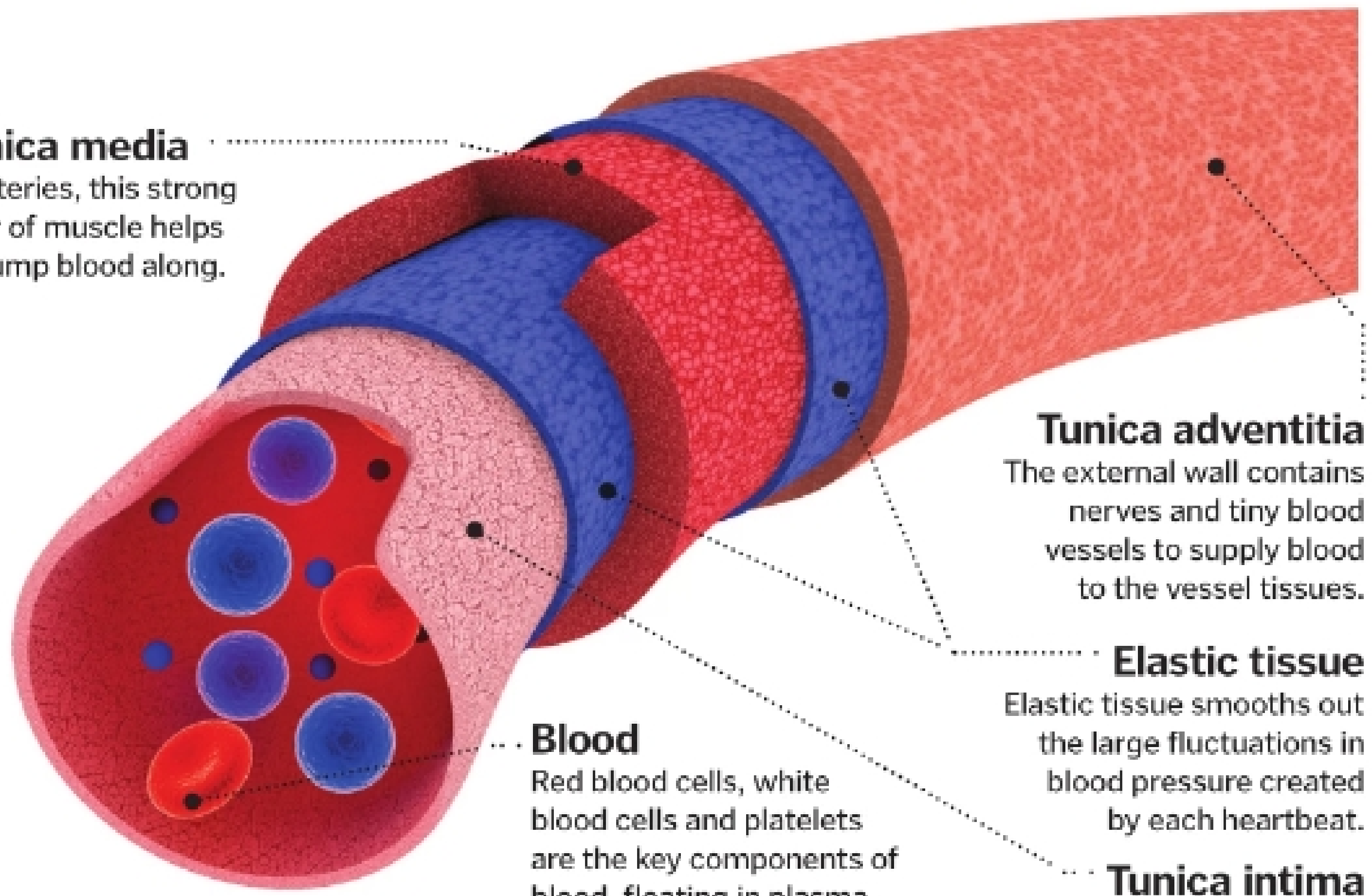
Outer core
Little is known about the neutron star's core, but it is thought neutrons here form a superfluid – a strange frictionless state of matter.

Inner core
At the star's heart, density peaks at around 4 x 10^{14} grams/cm^3.

15. Your blood vessels would circle the world two and a half times if laid end to end

Blood vessels are hollow tubes that carry blood around your body, delivering vital oxygen, nutrients and water. Arteries carry oxygen-rich blood away from the heart, minute capillaries deliver it to the tissues, while veins transport the deoxygenated blood and waste back to the heart for replenishing in the lungs.

The biggest vessel – the aorta – is 3,000 times wider than the smallest capillaries, where red blood cells (which carry the oxygen) have to line up in single file to squeeze through. These red blood cells are unusual in that they have no nucleus, meaning they can dedicate even more space to transporting oxygen.



Tunica media
In arteries, this strong layer of muscle helps to pump blood along.

Tunica adventitia
The external wall contains nerves and tiny blood vessels to supply blood to the vessel tissues.

Elastic tissue
Elastic tissue smooths out the large fluctuations in blood pressure created by each heartbeat.

Blood
Red blood cells, white blood cells and platelets are the key components of blood, floating in plasma.

Tunica intima
The innermost layer of the vessel is made of collagen and smooth muscle, allowing blood to flow unhindered.

16. Chalk is made of trillions of microscopic plankton fossils

Tiny single-celled algae called coccolithophores have lived in Earth's oceans for 200 million years. Unlike any other marine plant, they surround themselves with minuscule plates of calcite (coccoliths). Just under 100 million years ago, conditions were just right for coccolithophores to accumulate in a thick layer coating ocean floors in a white ooze. As further sediment built up on top, the pressure compressed the coccoliths to form rock, creating chalk deposits such as the white cliffs of Dover. Coccolithophores are just one of many prehistoric species that have been immortalised in fossil form, but how do we know how old they are? Over time, rock forms in horizontal layers, leaving older rocks at the bottom and younger rocks near the top. By studying the type of rock in which a fossil is found palaeontologists can roughly guess its age. Carbon dating estimates a fossil's age more precisely, based on the rate of decay of radioactive elements such as carbon-14.

17. In 2.3 billion years it will be too hot for life to exist on Earth

Over the coming hundreds of millions of years, the Sun will continue to get progressively brighter and hotter. In just over 2 billion years, temperatures will be high enough to evaporate our oceans, making life on Earth impossible. Our planet will become a vast desert similar to Mars today. As it expands into a red giant in the following few billion years, scientists predict that the Sun will finally engulf Earth altogether, spelling the definite end for our planet.

18 The 9m-long Stegosaurus had a brain the size of a walnut

This peaceful prehistoric herbivore was certainly big but not very clever. Animal intelligence is often estimated using the encephalisation quotient, or EQ, which compares an animal's brain weight to that of other 'typical' similarly sized creatures. Cold-blooded animals usually have lower EQs than warm-blooded mammals, but Stegosaurus still lags in the dino smarts rankings, with smaller carnivores like Velociraptor occupying the top spots.

19 Blonds have more hair

The average blond has 140,000 hairs on their head, compared to 110,000 for brunettes and 90,000 for redheads. Blond hair tends to be finer than other hair colours.

20 Every day a human produces 300 billion new cells

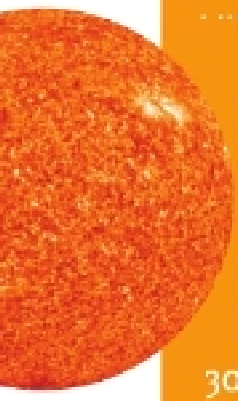
Your body renews itself continually as old cells are discarded and new ones created. On average, cells live for eight years. Some, however, last just a few days, whereas others (like brain cells) are with you for life.

21 An electric eel can produce 650 volts

Electric eels get their spark from specialised cells called electrocytes. These create a negative charge of about -0.1 volts by controlling the flow of ions across cell membranes. When an eel spots its prey, these thousands of tiny batteries join forces to deliver a mind-numbing shock.

22 $E=mc^2$

Einstein's famous equation states that energy (E) and matter (represented by m for mass) are one and the same (c is the speed of light). So matter can be viewed as an extremely concentrated form of energy. This principle is demonstrated in nuclear fission and fusion reactions which transform mass into vast amounts of energy.



23 It takes 8 minutes, 19 seconds for light to travel from the Sun to the Earth

In space, light travels at 300,000 kilometres (186,000 miles) per second. Even at this breakneck speed, covering the 150 million odd kilometres (93 million miles) between us and the Sun takes a considerable time. And eight minutes is still very little compared to the five and a half hours it takes for the Sun's light to reach Pluto.

24 Every living thing has at least one parasite living on/in it

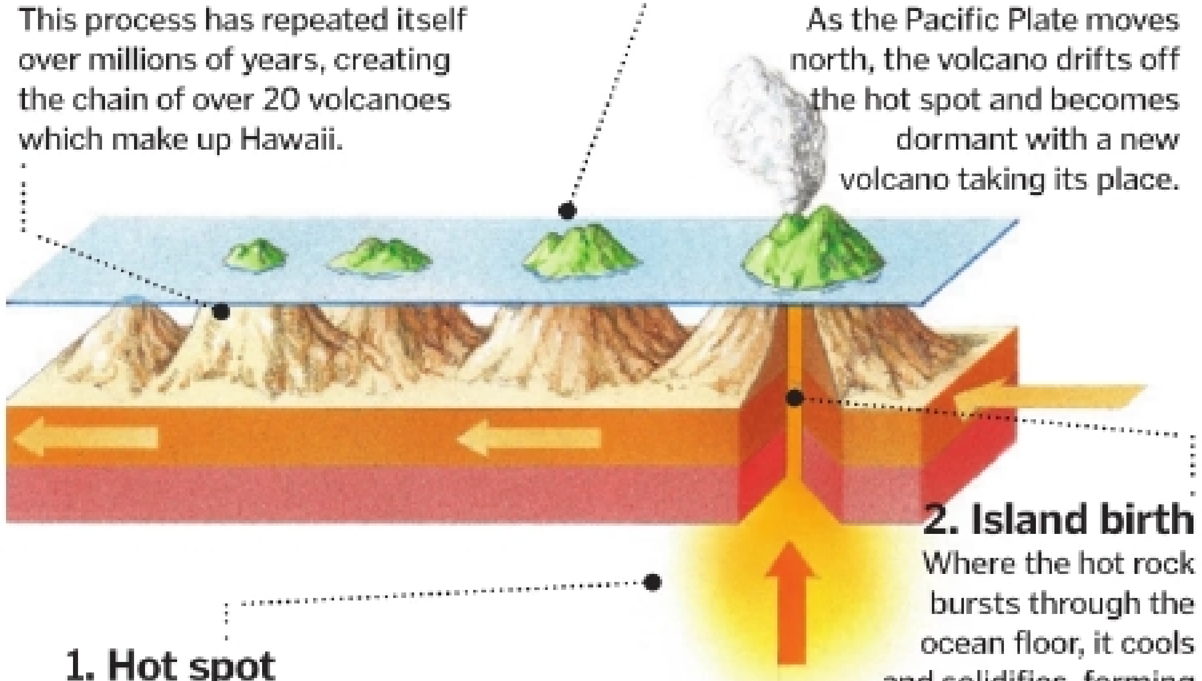
The majority of species on Earth are parasites, including everything from cuckoos to intestinal worms, bacteria and viruses. These organisms have co-evolved with their hosts, developing an arsenal of tricks to take advantage of them. In fact, many consider parasites to be a dominant force that drives evolution.

25 Space is not a complete vacuum

A vacuum is a space utterly devoid of any molecules, particles or any matter. Yet even the deepest recesses of our universe contain a few hydrogen atoms and photons per cubic metre.

26. Hawaii moves 7.5cm closer to Alaska every year

The Earth's crust is split into gigantic pieces called tectonic plates. These plates are in constant motion, propelled by currents in the Earth's upper mantle. Hot, less-dense rock rises before cooling and sinking, giving rise to circular convection currents which act like giant conveyor belts, slowly shifting the tectonic plates above them. Hawaii sits in the middle of the Pacific Plate, which is slowly drifting north-west towards the North American Plate, back to Alaska. The plates' pace is comparable to the speed at which our fingernails grow.



4. Building a chain
This process has repeated itself over millions of years, creating the chain of over 20 volcanoes which make up Hawaii.

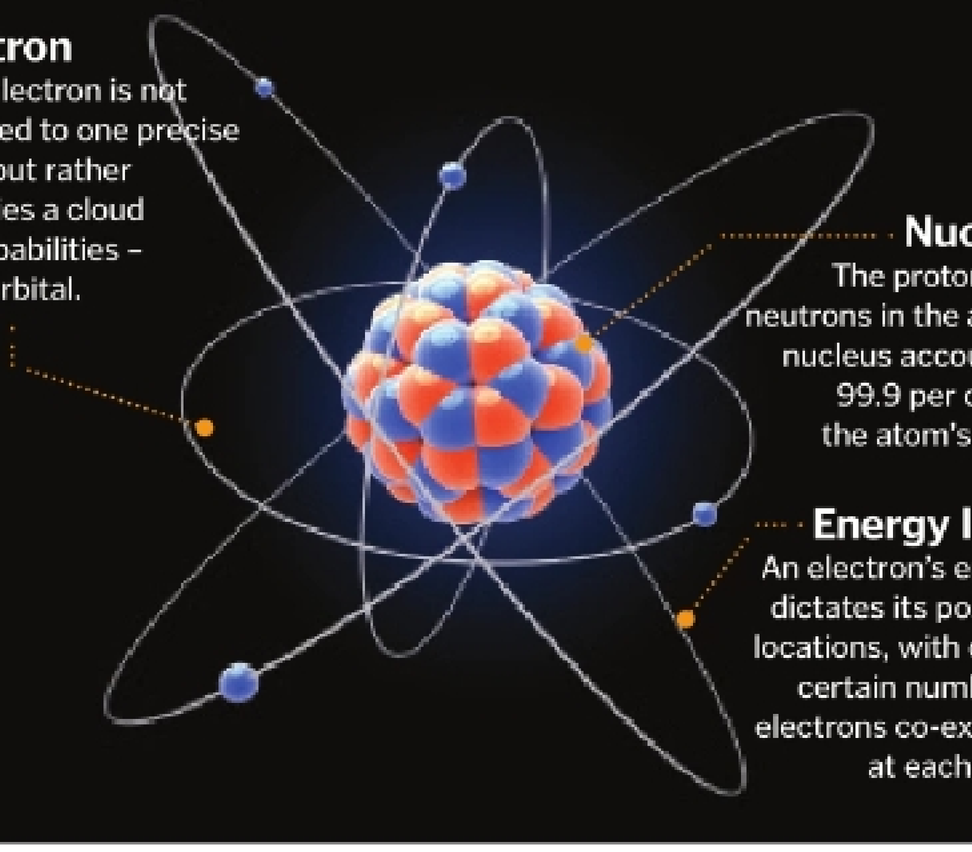
3. Tectonic movement
As the Pacific Plate moves north, the volcano drifts off the hot spot and becomes dormant with a new volcano taking its place.

2. Island birth
Where the hot rock bursts through the ocean floor, it cools and solidifies, forming a volcanic island.

1. Hot spot
The Hawaiian archipelago sits on top of a 'hot spot' where a plume of superheated rock rises through the Earth's crust.

27. If you took out all the empty space in our atoms, the human race could fit in the volume of a sugar cube

The atoms that make up the world around us seem solid, but are in fact over 99.99999 per cent empty space. An atom consists of a tiny, dense nucleus surrounded by a cloud of electrons, spread over a proportionately vast area. This is because as well as being particles, electrons act like waves. Electrons can only exist where the crests and troughs of these waves add up correctly. And instead of existing in one point, each electron's location is spread over a range of probabilities – an orbital. They thus occupy a huge amount of space.



Electron
Each electron is not confined to one precise point but rather occupies a cloud of probabilities – ie an orbital.

Nucleus
The protons and neutrons in the atom's nucleus account for 99.9 per cent of the atom's mass.

Energy level
An electron's energy dictates its possible locations, with only a certain number of electrons co-existing at each level.

28. The Sun's fuel won't last for ever

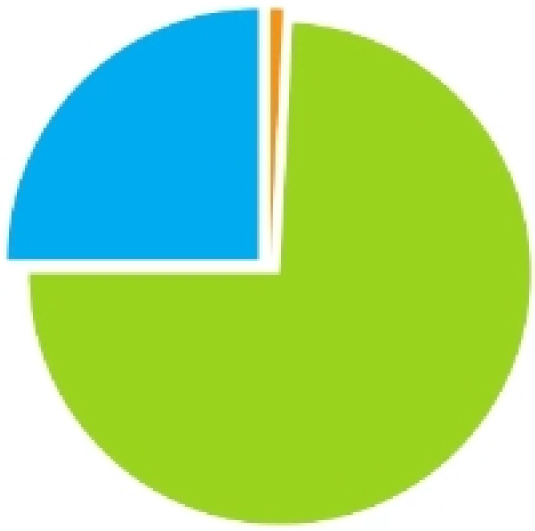
The Sun is fuelled by hydrogen, fusing 620 million tons of hydrogen nuclei into helium each second. This reaction produces solar radiation, which we experience as light and heat, but which also showers us with neutrinos – tiny particles that can pass through matter. In fact, at this very second billions of neutrinos are passing through your body. The Sun is about 4.5 billion years old and, after comparing it to similar stars in our galaxy, astrophysicists reckon it is about halfway through its hydrogen burning stage. That leaves us another 5 billion years before its fuel begins to run low.

Stellar cloud
This dense cloud of gas contracts under gravity, giving birth to a new star.

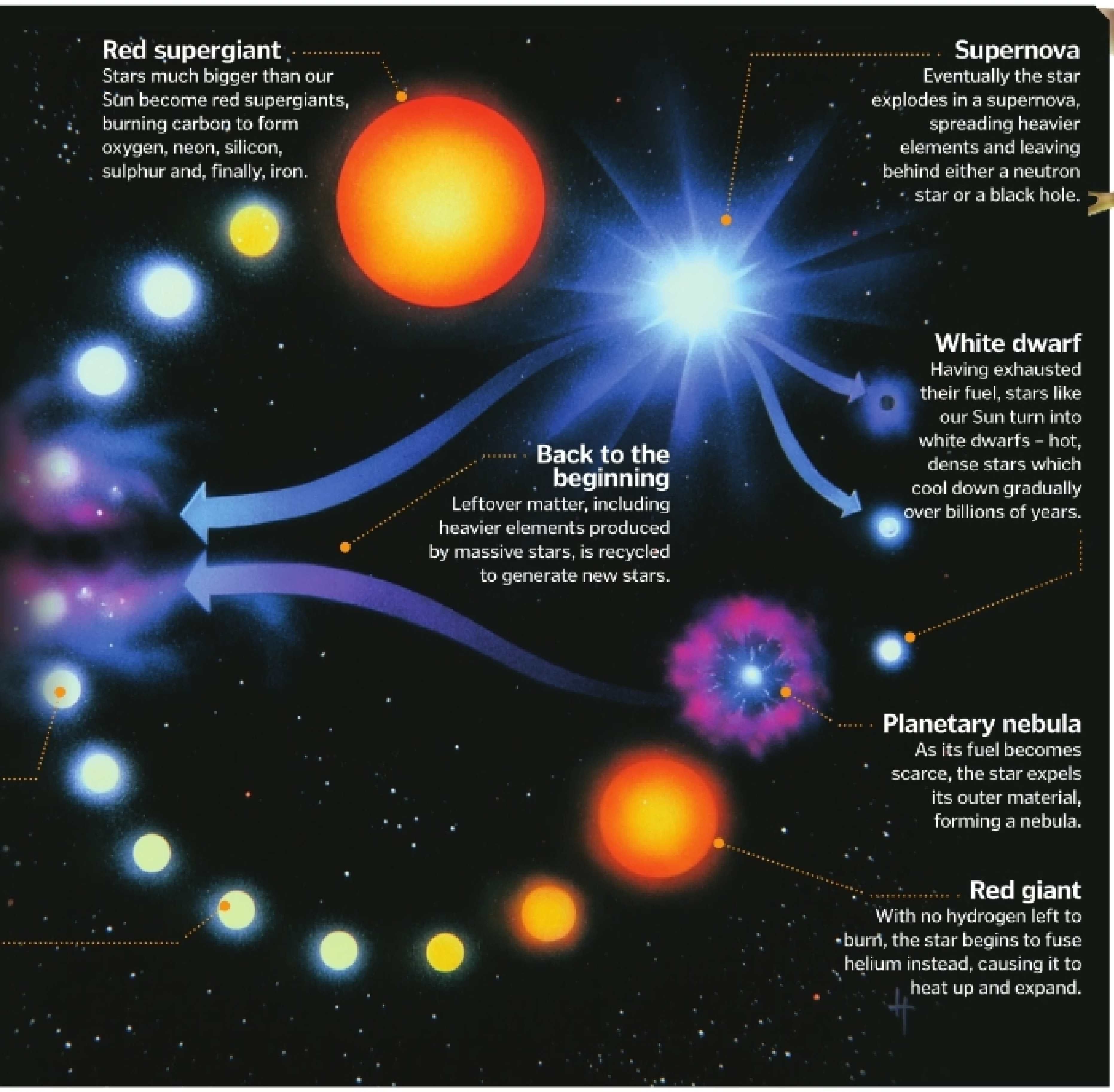
Protostar
If the star is massive enough, its temperature reaches 10 million Kelvin, allowing the star to fuse hydrogen.

Main-sequence star
Stars similar to our Sun in size continue to burn hydrogen until their supplies run out.

29. Three-quarters of the universe is hydrogen



🟩 **Hydrogen: 74%**
🟦 **Helium: 25%**
🟧 **Heavier elements: 1%**



Red supergiant
Stars much bigger than our Sun become red supergiants, burning carbon to form oxygen, neon, silicon, sulphur and, finally, iron.

Supernova
Eventually the star explodes in a supernova, spreading heavier elements and leaving behind either a neutron star or a black hole.

White dwarf
Having exhausted their fuel, stars like our Sun turn into white dwarfs – hot, dense stars which cool down gradually over billions of years.

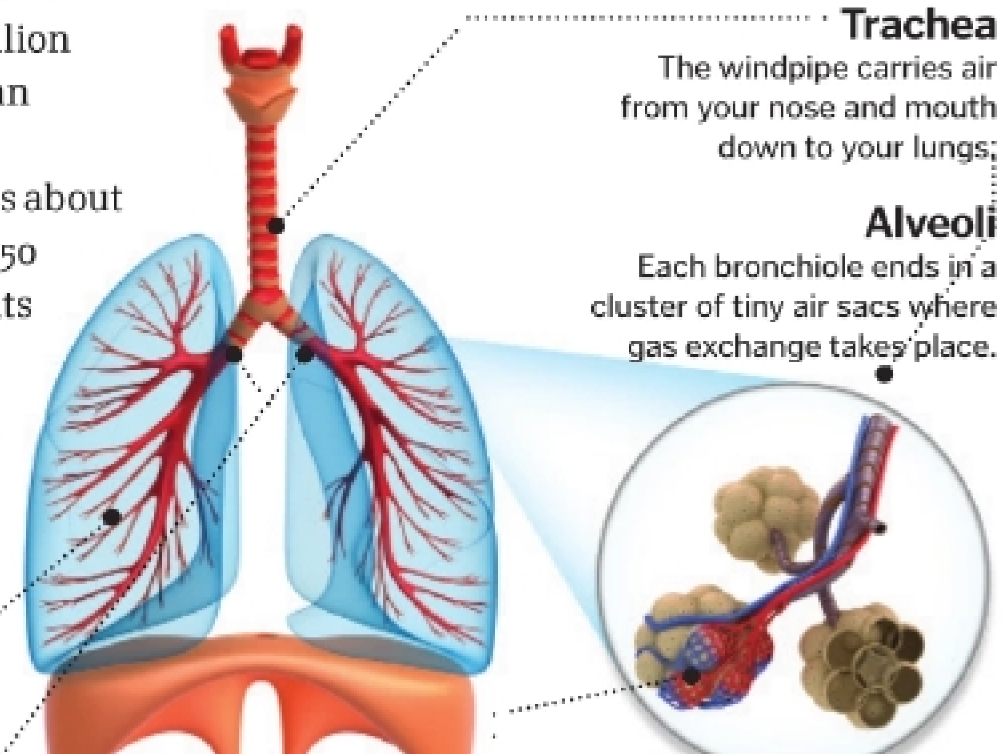
Back to the beginning
Leftover matter, including heavier elements produced by massive stars, is recycled to generate new stars.

Planetary nebula
As its fuel becomes scarce, the star expels its outer material, forming a nebula.

Red giant
With no hydrogen left to burn, the star begins to fuse helium instead, causing it to heat up and expand.

30. The surface area of the lungs is equivalent to a tennis court

The lungs facilitate gas exchange between the air we breathe and our blood, allowing oxygen to enter the body and carbon dioxide to leave. This exchange takes place inside 700 million alveoli, tiny hollow air sacs wrapped in an intricate network of blood vessels. The membrane across which the gases pass is about two micrometres (0.00008 inches) thick, 50 times thinner than a sheet of paper and its total surface area adds up to 70 square metres (750 square feet).



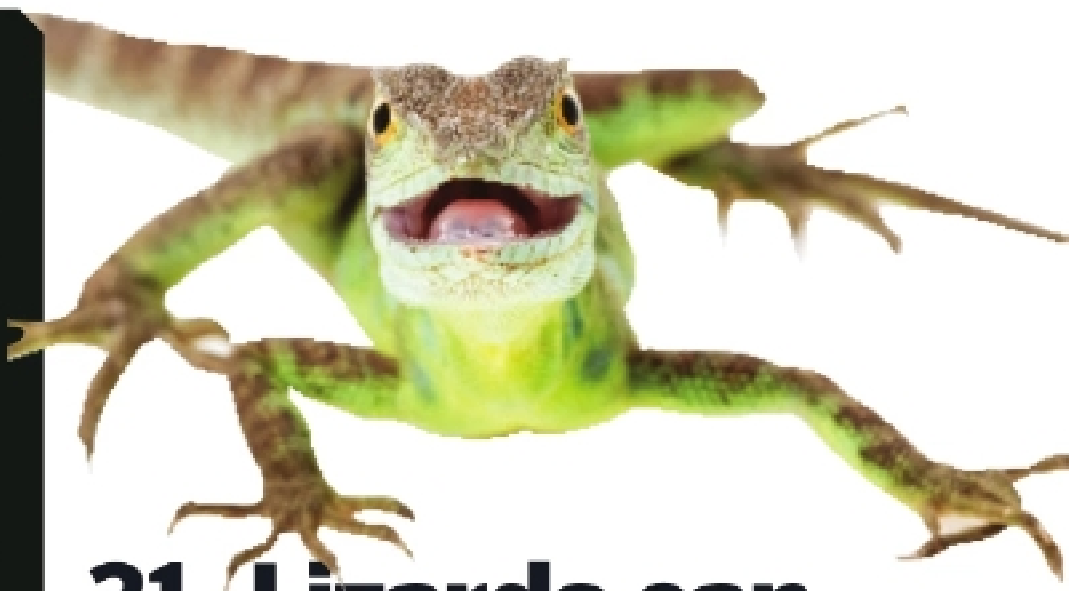
Trachea
The windpipe carries air from your nose and mouth down to your lungs.

Alveoli
Each bronchiole ends in a cluster of tiny air sacs where gas exchange takes place.

Bronchioles
As the bronchi branch out, they form bronchioles, of which there are about 30,000 in each lung.

Bronchi
The bronchi connect both left and right lungs to the trachea.

Capillaries
A network of blood vessels surrounds the alveoli, transporting oxygen and carbon dioxide in and out of the body.



31. Lizards can walk on water

Fringes of skin on the outer edges of the Central/South American basilisk lizard's hind toes increase the feet's surface area, making this impressive trick possible. The lizard slaps its feet down as it runs, creating an upward force and trapping bubbles of air. Its feet also push sideways, helping it to stay upright.

32. The universe expands in all directions hourly

Our universe is growing continually, with the space between objects expanding just like an inflated balloon. This fact wasn't discovered until the 1920s, when Edwin Hubble observed that distant galaxies are rushing away from us. Not only that, but the farther a galaxy is from us, the faster it moves away. This groundbreaking observation also implied that the whole universe must once have been contained in a single point, giving rise to the Big Bang theory. According to this model, the cosmos was born 13.7 billion years ago, with all its energy compressed into one incredibly hot and dense point which has been expanding and cooling ever since.

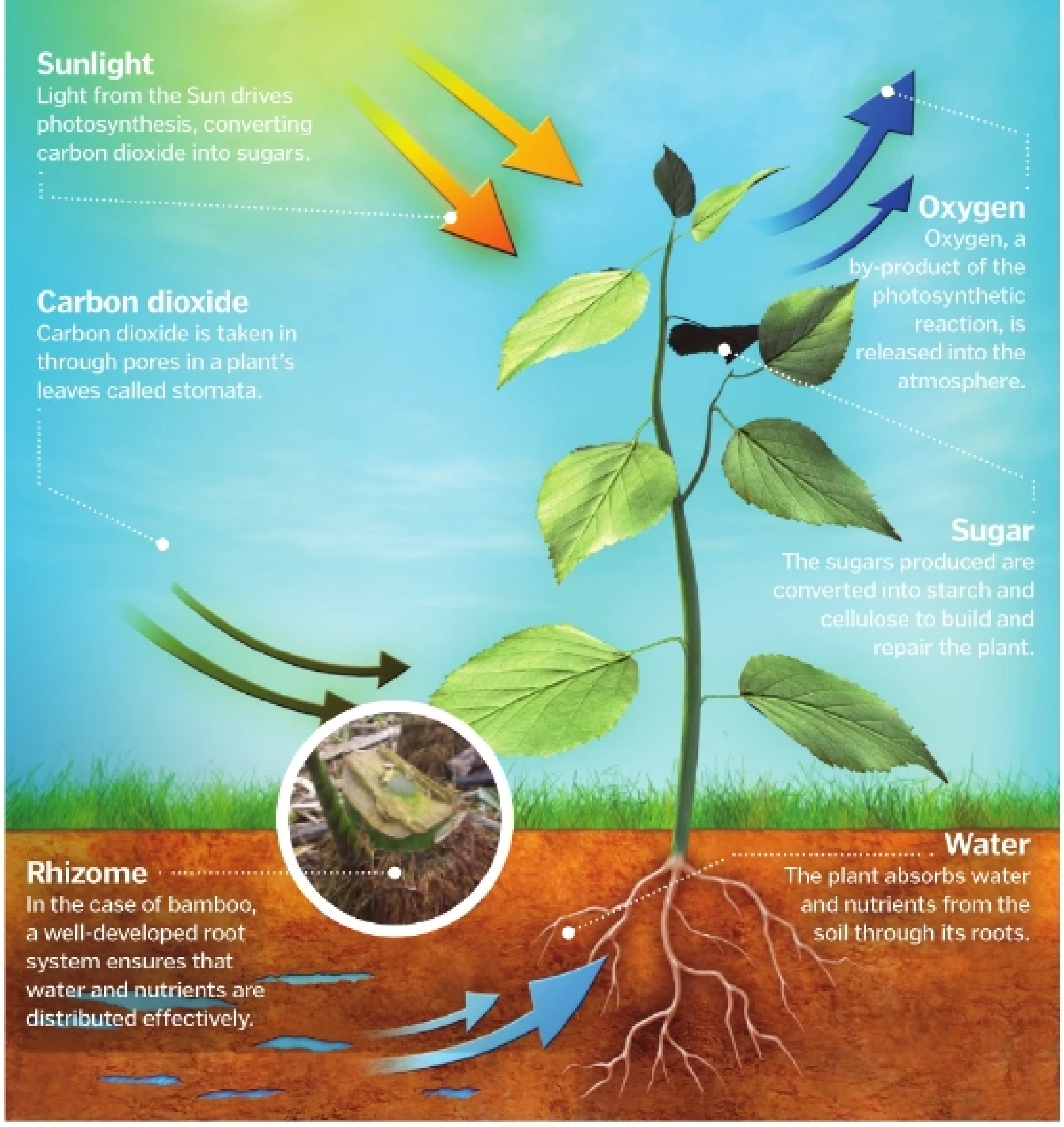
Even more surprisingly, the universe's expansion is accelerating. The reason behind the universe's swelling has been dubbed 'dark energy', but very little is known about this mysterious force which is thought to occupy a staggering 70 per cent of the universe.

33. At light speed it would take 2.5 million years to reach our galactic neighbour

Andromeda is one of our galaxy's closest neighbours, but popping over to borrow some sugar would be quite a trek. By measuring the apparent brightness of its stars, astronomers have estimated that Andromeda is 2.4 x 10^{19} kilometres (1.5 x 10^{19} miles) away. To avoid drowning in zeros, scientists prefer to measure such distances in light years. As its name suggests, a light year is the distance travelled by light in one year – in other words, a whopping 9.5 trillion kilometres (about six trillion miles) – making Andromeda 2.5 million light years away.

34. Bamboo is the fastest-growing plant on Earth

While trees grow mostly from the end of their branches, bamboo is actually a grass, so it grows very differently. A bamboo shoot is split into segments which can all host cell division (ie growth), allowing the bamboo to extend a bit like a telescope Equally vital to its record-smashing growth rates (60 centimetres/24 inches per day) is the plant's rhizome, an underground network of roots connecting a cluster of canes. Like all plants, bamboo gets its energy from photosynthesis, but the rhizome enables it to distribute nutrients and water where they are most needed.



Sunlight
Light from the Sun drives photosynthesis, converting carbon dioxide into sugars.

Carbon dioxide
Carbon dioxide is taken in through pores in a plant's leaves called stomata.

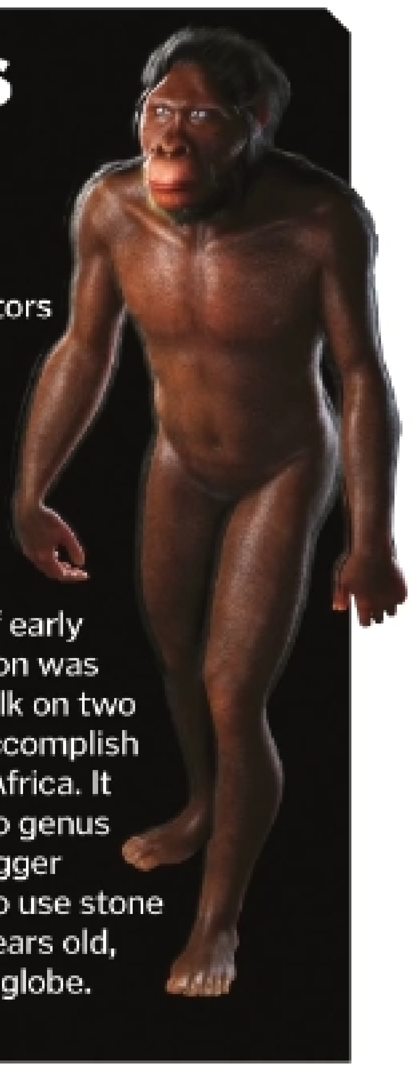
Oxygen
Oxygen, a by-product of the photosynthetic reaction, is released into the atmosphere.

Sugar
The sugars produced are converted into starch and cellulose to build and repair the plant.

Water
The plant absorbs water and nutrients from the soil through its roots.

Rhizome
In the case of bamboo, a well-developed root system ensures that water and nutrients are distributed effectively.

35. Early humans date back up to 7 million years



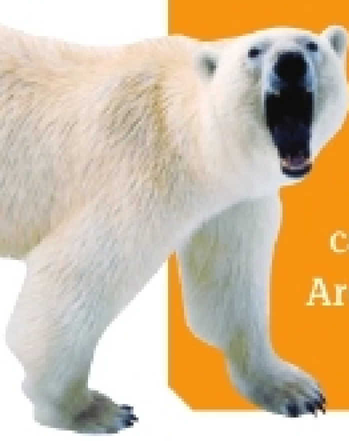
It's difficult to define the point when our ancestors became 'human', but one important milestone occurred when the human lineage diverged from that of our closest living relatives: chimpanzees. The last ancestor we shared with chimps lived about 7 million years ago – a relatively short time ago in the 2 billion odd years since life first appeared on Earth. Since then there have been 15-20 different species of early hominid. Another key chapter in human evolution was the beginnings of bipedalism – the ability to walk on two feet. Australopithecus was the first genus to accomplish this feat around 4 million years ago in eastern Africa. It wasn't until 2.4 million years ago that the Homo genus appeared. Their distinguishing feature was a bigger brain and they were the first of our ancestors to use stone tools. Homo sapiens are only about 200,000 years old, emerging in Africa before migrating across the globe.

36. Gravity is only 3% weaker 100km above the Earth

According to the laws of gravity, any two objects with mass attract each other. For this effect to be noticeable, one of the objects needs to have a considerable mass; at roughly 6×10^{24} kilograms (1.3×10^{25} pounds), our planet fits the bill nicely. Gravity decreases the farther you are from Earth's centre, but given that standing on its surface you are already 6,370 kilometres (3,960 miles) away from the core, a 100-kilometre (62-mile) increase makes a relatively small difference. Air pressure, on the other hand, is caused by the sheer weight of the air molecules above you. Standing at sea level, the air above you causes a pressure equivalent to about 1,000 kilograms (2,205 pounds). Luckily this pressure pushes on us in all directions. Water weighs about 800 times more than air, so exerts a far greater pressure; in fact, at just ten metres (33 feet) underwater, the pressure would be double.

37 Polar bears are nearly undetectable by infrared cameras

Thermal cameras detect the heat lost by a subject as infrared, but polar bears are experts at conserving heat. The bears keep warm due to a thick layer of blubber under the skin. Add to this a dense fur coat and they can endure the chilliest Arctic day.



38 Stomach acid is strong enough to dissolve razor blades

Your stomach digests food thanks to highly corrosive hydrochloric acid with a pH of 2 to 3. This acid also attacks your stomach lining, which protects itself by secreting an alkali bicarbonate solution. The lining still needs to be replaced continually, and it entirely renews itself every four days.

39 Alpha radiation can be deadly but a sheet of paper can stop it

As an unstable radioactive atom decays, it ejects particles and energy, producing alpha, beta and gamma radiation. Alpha particles carry the strongest charge so can cause the most harm. Their large mass, however, stops them penetrating very far into matter, so they're only likely to cause damage if ingested.

40 The Earth is a giant magnet

Earth's inner core is a sphere of solid iron, surrounded by liquid iron. Variations in temperature and density create currents in this iron, which in turn produce electrical currents. Lined up by the Earth's spin, these currents combine to create a magnetic field, used by compass needles worldwide.

41. Nerve impulses can travel as fast as 200mph

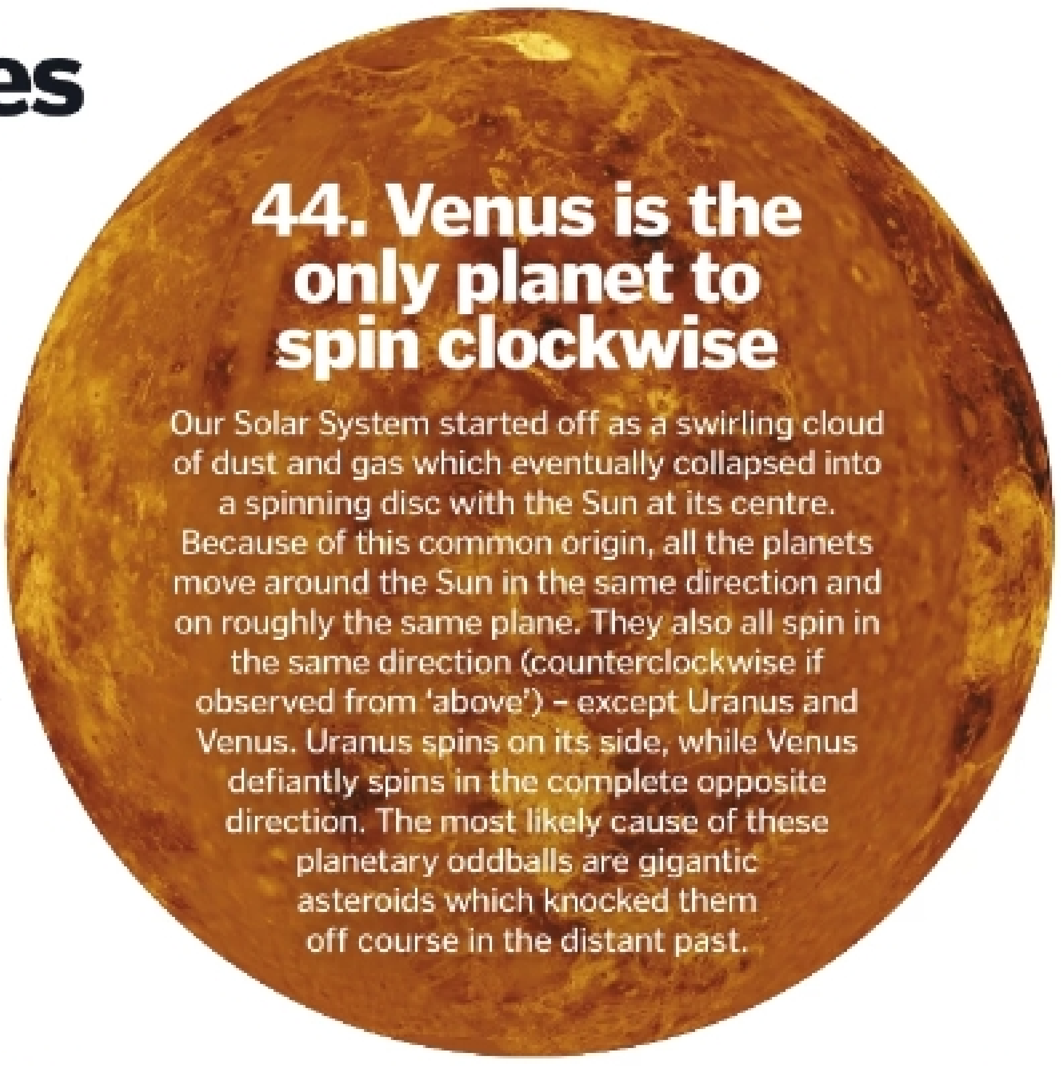
Electrical signals are the body's principal means of communication, controlling everything from your heartbeat to pain. The nervous system is a network of millions of neurons – tiny messenger cells which transmit information using electrical signals called nerve impulses. By controlling the flow of ions, each neuron can build up an electrical charge and transmit it down its axon, a long branch which passes the impulse on to the next neuron. The speed of nervous impulses varies but the fastest signals are carried within motor neurons. These relay messages from the brain telling muscles to contract.

42. The difference between tides can be as great as 17m

The extreme tides in eastern Canada's Bay of Fundy are caused by tidal resonance. All over the globe, high tides occur every 12 and a half hours. The Bay of Fundy is peculiar in that it takes 13 hours for seawater to slosh into the mouth of the bay, to its head and then back out to sea, roughly matching the rhythm of the tides. As each tide rises, it therefore amplifies the water's sloshing motion – just like someone giving a child on a swing a small push at just the right moment. These two bulges result in two high tides, which sweep around the globe at intervals of 12 and a half hours.

43. Energy is neither created nor destroyed

Known as the law of conservation of energy, this principle is key to understanding our entire universe. Energy can't be created or destroyed, but it can change form. Think about a moving car, for example. Chemical energy contained in the fuel is converted into mechanical energy by the motor. This propels the car forward, transforming into kinetic energy. Step on the brake and this energy is converted into heat and sound. Energy sometimes seems to disappear, but this usually means it is being stored as potential energy, like a stretched spring. Although energy is never destroyed, it can be 'lost' when converted into unwanted forms, eg a traditional light bulb expends lots of energy as heat rather than light.



44. Venus is the only planet to spin clockwise

Our Solar System started off as a swirling cloud of dust and gas which eventually collapsed into a spinning disc with the Sun at its centre. Because of this common origin, all the planets move around the Sun in the same direction and on roughly the same plane. They also all spin in the same direction (counterclockwise if observed from 'above') – except Uranus and Venus. Uranus spins on its side, while Venus defiantly spins in the complete opposite direction. The most likely cause of these planetary oddballs are gigantic asteroids which knocked them off course in the distant past.

45. Sound moves faster in water than air

Sound is a vibration. It travels as a compression (or longitudinal) wave when particles (molecules or atoms) collide with one another, passing on the vibration. Sound therefore can't cross a vacuum but needs a medium to pass through, and its speed is determined by the properties of that medium. In general, sound travels fastest in a solid, then a liquid and slowest in a gas. Inside a solid, particles are packed tightly together, meaning vibrations are passed on easily. In a liquid particles are more spaced out, making it harder for vibrations to be transmitted from one particle to the next, but they can travel faster than when passing through a gaseous medium like air.

Air

At room temperature, sound travels through air at 344m (1,129ft)/sec. Lower the thermostat and the drop in air density slows it down significantly.

Water

Sound travels at 1,500m (4,921ft)/sec through water, as it's a much denser medium than air.

Steel

The rigid structure of steel allows sound waves to travel at a swift 6,000m (19,685ft)/sec – 17 times faster than through air.

46. The Great Barrier Reef is the biggest living structure

Stretching from the north-east coast of Australia, the Great Barrier Reef is the world's largest coral reef system. The 2,600-kilometre (1,616-mile)-long structure is made of millions of tiny living animals – coral polyps – whose hard calcium carbonate exoskeletons give the reef its structure. Like all coral reefs, the Great Barrier Reef provides an incredible range of marine habitats. As well as 400 species of coral alone, the Great Barrier Reef supports thousands of other animals and plants including over 1,500 fish species.

47 A flea can accelerate faster than the Space Shuttle

A jumping flea reaches dizzying heights of about eight centimetres (three inches) in a millisecond. Acceleration is the change in speed of an object over time, often measured in 'g's, with one g equal to the acceleration caused by gravity on Earth (9.8 metres/32.2 feet per square second). Fleas experience 100 g, while the Space Shuttle peaked at around 5 g. The flea's secret is a stretchy rubber-like protein which allows it to store and release energy like a spring.

48 If you could drive up, you'd arrive in space in about an hour

The Kármán Line at 100 kilometres (62 miles) in altitude is generally accepted as the boundary of space. Driving at a leisurely 90 kilometres (56 miles) per hour, a trip to space would therefore take just 67 minutes.

49 Stretched out, the DNA from one human cell would be 2m

The DNA in each cell contains all the instructions necessary to build a person, coiled up tightly inside chromosomes in the nucleus. There are roughly 3 billion chemical letters (bases) in your DNA.

50 The gas cloud Sagittarius B2 contains a billion, billion, billion litres of alcohol

The alcohol in question is vinyl alcohol as opposed to ethanol. Although scientists don't yet know how it got there, it's thought these molecules could provide clues as to how complex organic compounds form in space.

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25 EARTH SHATTERING FACTS

1. What's the deepest epicentre on record?
750km

2. Do more earthquakes occur in hot weather?
No

Can earthquakes make days shorter? Are there quakes elsewhere in space? Find out now…

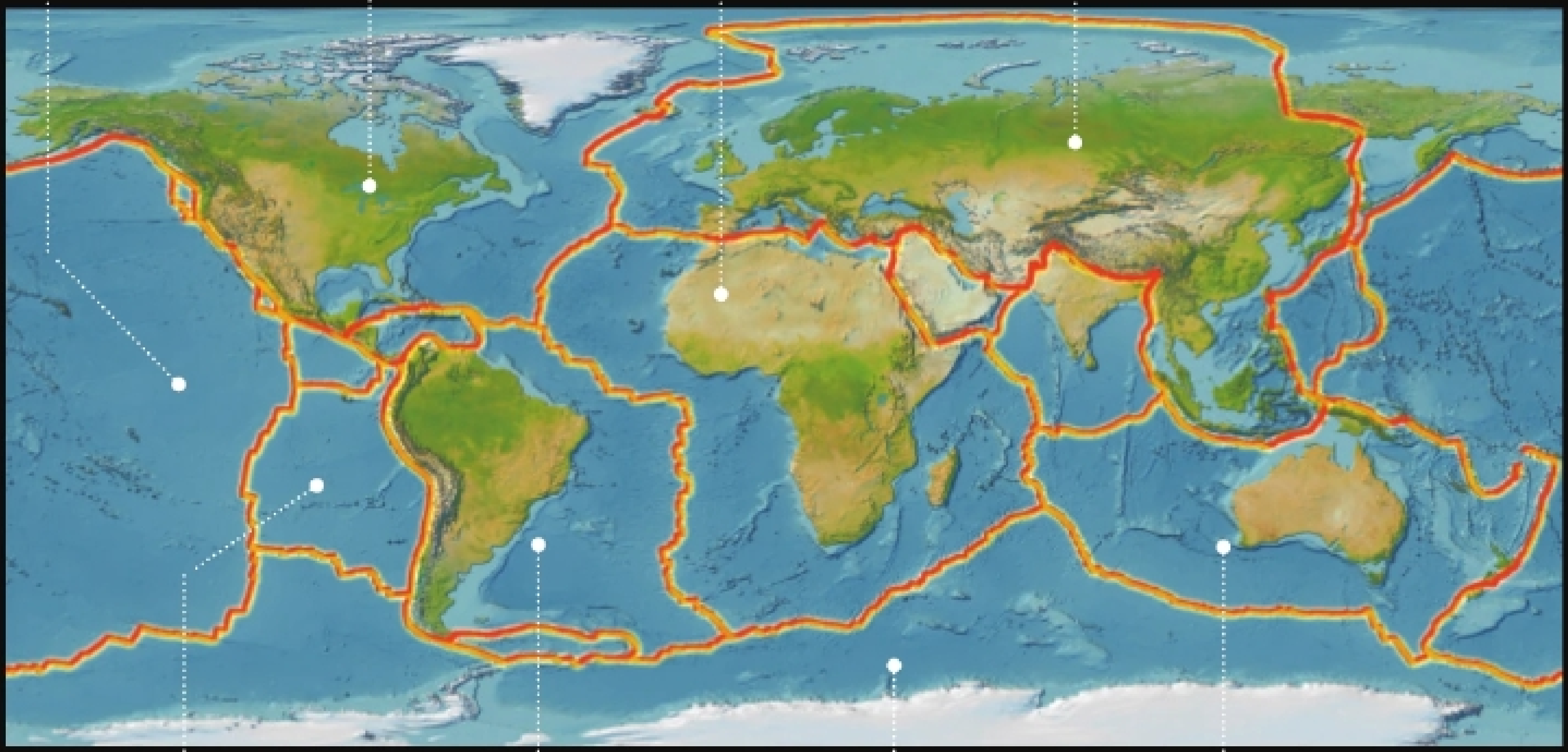
The earthquake and tsunami that devastated north-east Japan in March 2011 demonstrate the terrifying power of these natural phenomena. Almost 16,000 people died and more than a million buildings wholly or partly collapsed.

A year after the event, 330,000 people were still living in hotels or in other temporary accommodation, unable to return home. A further 3,000 people were still listed as missing. The gigantic tsunami waves spawned by the earthquake inundated the power supply and cooling of three reactors at the Fukushima Daiichi power station. The subsequent nuclear accident – the worst since Chernobyl – caused worldwide panic.

Earthquakes are unstoppable and strike with little or no warning, but we know a growing amount about how they work. Scientists have developed networks of sensors for monitoring ground movements, changes in groundwater and magnetic fields, which may indicate an impending quake. Engineers, meanwhile, have created new forms of architecture to resist earthquakes when they do strike. So without further ado, let's learn some earth-shattering facts…

3. What is Earth's crust made of?

The crust consists of rock broken into moving slabs, called plates. These plates float on the denser rocks of the mantle, a sticky layer lying between the planet's core and the crust. Granite is the commonest rock in the crust that makes up Earth's continents. This continental crust is an average 35 kilometres (22 miles) thick, deepest beneath mountain ranges. Ocean floor crust is thinner – on average six kilometres (four miles) – and mainly made of denser volcanic rocks, such as basalt. Granite is 75 per cent oxygen and silicon. Basalt is denser as the silicon is contaminated with heavier elements like iron.



Pacific Plate
Earth's biggest plate is among the fastest moving, travelling north-west some seven centimetres (three inches) annually.

North American Plate
The continent of North America and some of the Atlantic Ocean floor sit on this plate.

African Plate
This plate carrying the African continent carries some of the world's most ancient crust – up to 3.6 billion years old.

Eurasian Plate
The Himalayas, Earth's highest mountain range, is rising as the Indian Plate thrusts beneath the Eurasian Plate.

Nazca Plate
The Nazca Plate located off South America's west coast is one of several smaller plates.

South American Plate
The collision of South America with the Nazca Plate is lifting up the Andes, our planet's longest mountain range.

Antarctic Plate
Until 45 million years ago, the Antarctic Plate was joined to the Australian Plate.

Indo-Australian Plate
The Indo-Australian Plate may be splitting apart to form separate Indian and Australian Plates.

4. Did the 2011 quake in Japan shorten the days on Earth?

Yes, but you're unlikely to notice. Every day is now 1.8 microseconds shorter, according to NASA. The Japan earthquake made Earth spin slightly faster by changing its rotation around an imaginary line called the figure axis. The Earth's mass is balanced around the figure axis, and it wobbles as it spins. That wobble naturally changes one metre (3.3 feet) a year due to moving glaciers and ocean currents. The 2011 Tohoku earthquake moved the ocean bed near Japan as much as 16 metres (53 feet) vertically and 50 metres (164 feet) horizontally – that's the equivalent horizontal distance to an Olympic swimming pool! The shifting ocean bed increased Earth's wobble around the figure axis by 17 centimetres (6.7 inches). As the wobble grew, Earth sped up its rotation. It's the same principle as when a figure skater pulls their arms closer to their body in order to spin faster.

5. What is the shadow zone of an earthquake?

A shadow zone is the location on the Earth's surface at an angle of 104-140 degrees from a quake's origin that doesn't receive any S-waves or direct P-waves. S and P-waves are seismic waves that can travel through the ground. Seismic waves are shockwaves created when a fault suddenly moves. The shadow zone occurs as S-waves can't pass through the Earth's liquid outer core, while P-waves are refracted by the liquid core.

6. Where is the quake capital?

Around 90 per cent of earthquakes occur on the so-called Ring of Fire, a belt of seismic activity surrounding the Pacific Plate. The Ring of Fire is a massive subduction zone where the Pacific Plate collides with and slides beneath several other crustal plates. Most earthquakes are measured in Japan, which lies on the Ring of Fire at the junction of the Pacific, Philippine, Eurasian and Okhotsk Plates. Japan has a dense earthquake-monitoring network, which means scientists can detect even small quakes. The volcanic island chain of Indonesia probably experiences the most earthquakes based on landmass, however it has fewer instruments for measuring them.

7. Are earthquakes more likely to occur in the morning?

No

8 What are tremors?

A tremor is simply another word for an earthquake. It's also another word for the vibrations you experience when a quake hits. The earth trembles because movement energy is released in an earthquake, causing the ground to vibrate.

9 How can scientists tell how far away an earthquake occurred?

Scientists use a seismometer to record earthquake waves called P and S-waves. P-waves travel faster than S-waves and can pass through liquids. By measuring the delay between the P and S-waves arriving, they can calculate the distance the waves travelled.

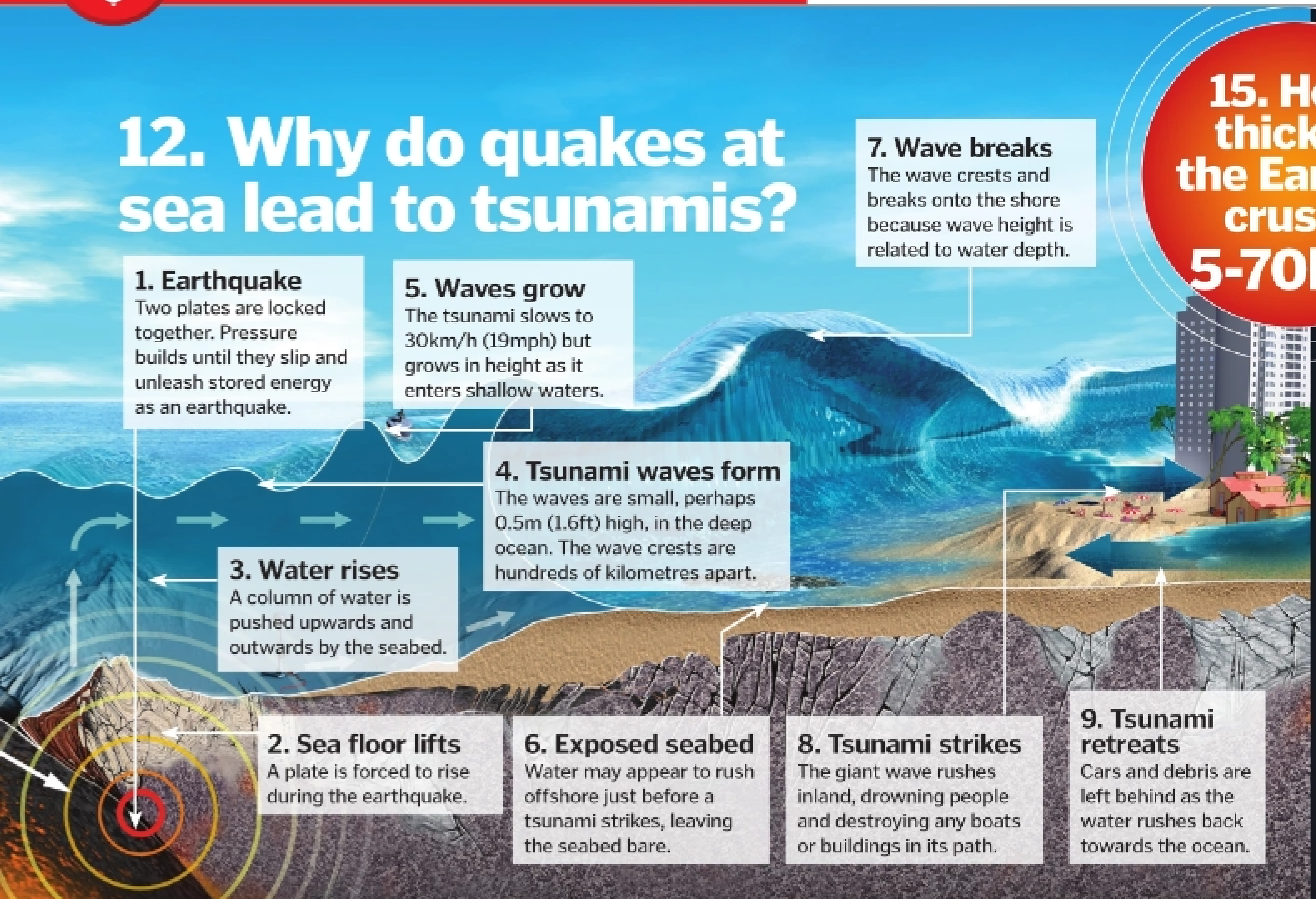
10 What's the earliest recorded major earthquake in history?

The first earthquake described was in China in 1177 BCE. By the 17th century, descriptions of the effects of earthquakes were published worldwide, although of course these accounts were often exaggerated and less detailed than data recorded today.

11 What do the lines on a seismometer reading represent?

The wiggly lines on a seismogram represent the waves recorded. The first big wiggles are P-waves. The second set of wiggles are S-waves. If the latter are absent, the quake happened on the other side of the planet.

12. Why do quakes at sea lead to tsunamis?



1. Earthquake
Two plates are locked together. Pressure builds until they slip and unleash stored energy as an earthquake.

2. Sea floor lifts
A plate is forced to rise during the earthquake.

3. Water rises
A column of water is pushed upwards and outwards by the seabed.

4. Tsunami waves form
The waves are small, perhaps 0.5m (1.6ft) high, in the deep ocean. The wave crests are hundreds of kilometres apart.

5. Waves grow
The tsunami slows to 30km/h (19mph) but grows in height as it enters shallow waters.

6. Exposed seabed
Water may appear to rush offshore just before a tsunami strikes, leaving the seabed bare.

7. Wave breaks
The wave crests and breaks onto the shore because wave height is related to water depth.

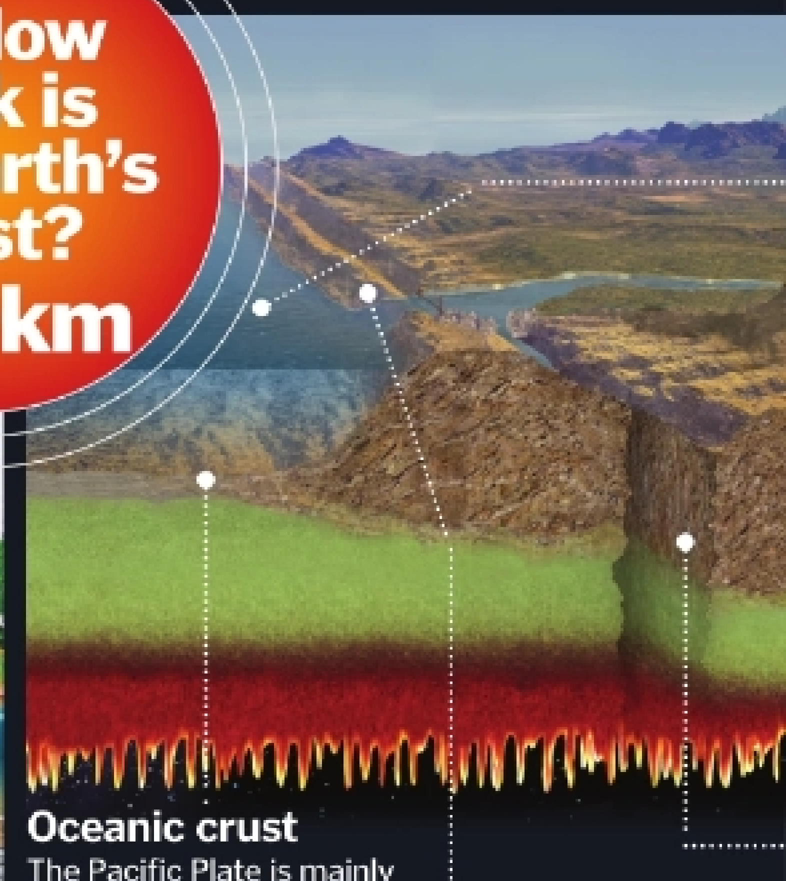
8. Tsunami strikes
The giant wave rushes inland, drowning people and destroying any boats or buildings in its path.

9. Tsunami retreats
Cars and debris are left behind as the water rushes back towards the ocean.

Earthquakes trigger tsunamis by generating ripples, similar to the effect of sloshing water in a glass. Tsunamis are giant waves, which can cross oceans at speeds similar to jet aircraft, up to 700 kilometres (435 miles) per hour, and reach heights of 20 metres (66 feet) as they hit the coast. They sweep inland faster than running speed, carrying away people and buildings alike. For example, the 2004 Indian Ocean tsunami claimed 300,000 lives and made nearly 2 million more homeless.

15. How thick is the Earth's crust?

5-70km



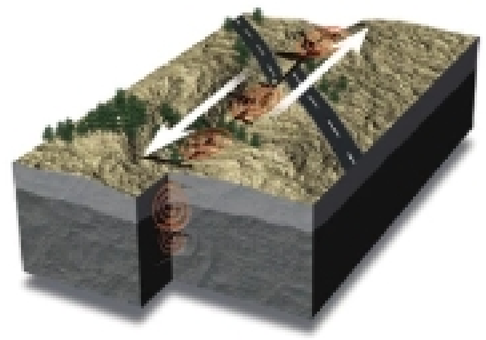
Oceanic crust
The Pacific Plate is mainly oceanic crust, which is younger and thinner than continental crust – about 5-10km (3-6mi) thick.

San Andreas Fault
The San Andreas is a strike-slip fault created by the Pacific and North American Plates sliding past each other.

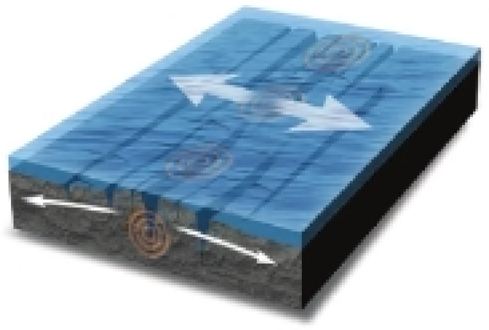
16. How many quakes occur each year?

500,000

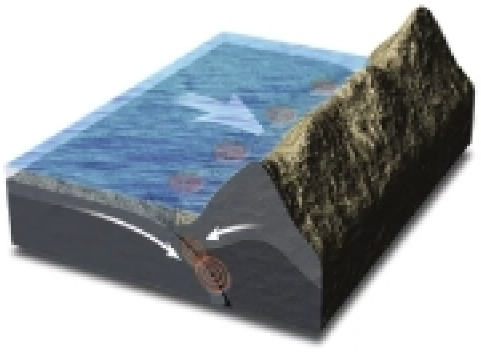
13. Are there different types of earthquake?



Strike-slip fault
Roads can be sheared apart along strike-slip faults. They're straight cracks in the crust where two plates are sliding horizontally past each other. Every time a section of the fault moves, an earthquake occurs.



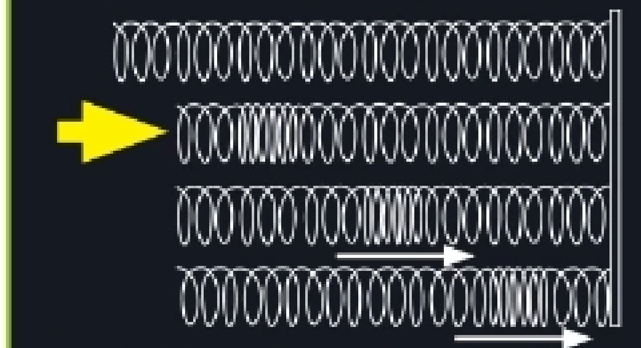
Normal fault
Earth's brittle crust becomes fractured along fault lines. Quakes occur along a normal fault when the two sides move apart. Rock slabs sitting above the fault slide down in the direction the plates are moving, like at the Mid-Atlantic Ridge.



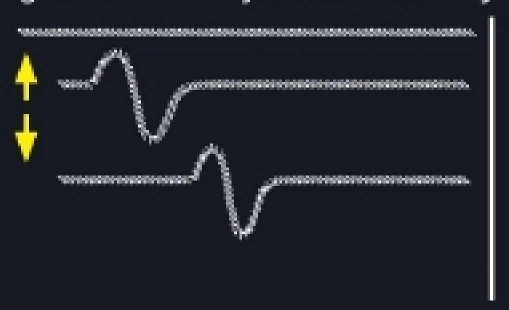
Thrust fault
The 2011 Tohoku quake ruptured a thrust fault in a subduction zone. These zones are associated with Earth's most violent quakes as oceanic crust grinds beneath continental crust, creating great friction. Huge stresses can build here and release the same energy as a thousand hydrogen bombs!

14. How do P and S-waves move?

Primary (compressional) waves
P-waves are the fastest waves created by an earthquake. They travel through the Earth's interior and can pass through both solid and molten rock. They shake the ground back and forth – like a Slinky – in their travel direction, but do little damage as they only move buildings up and down.

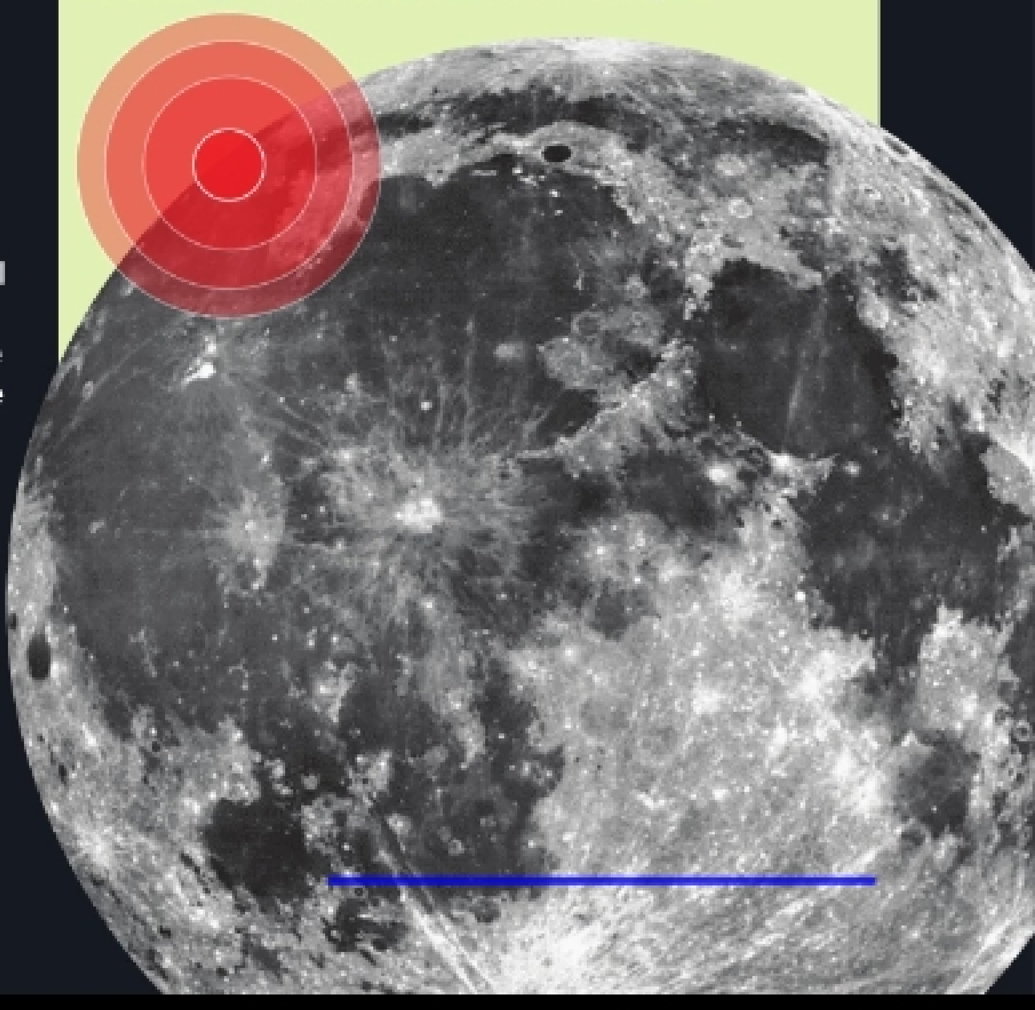


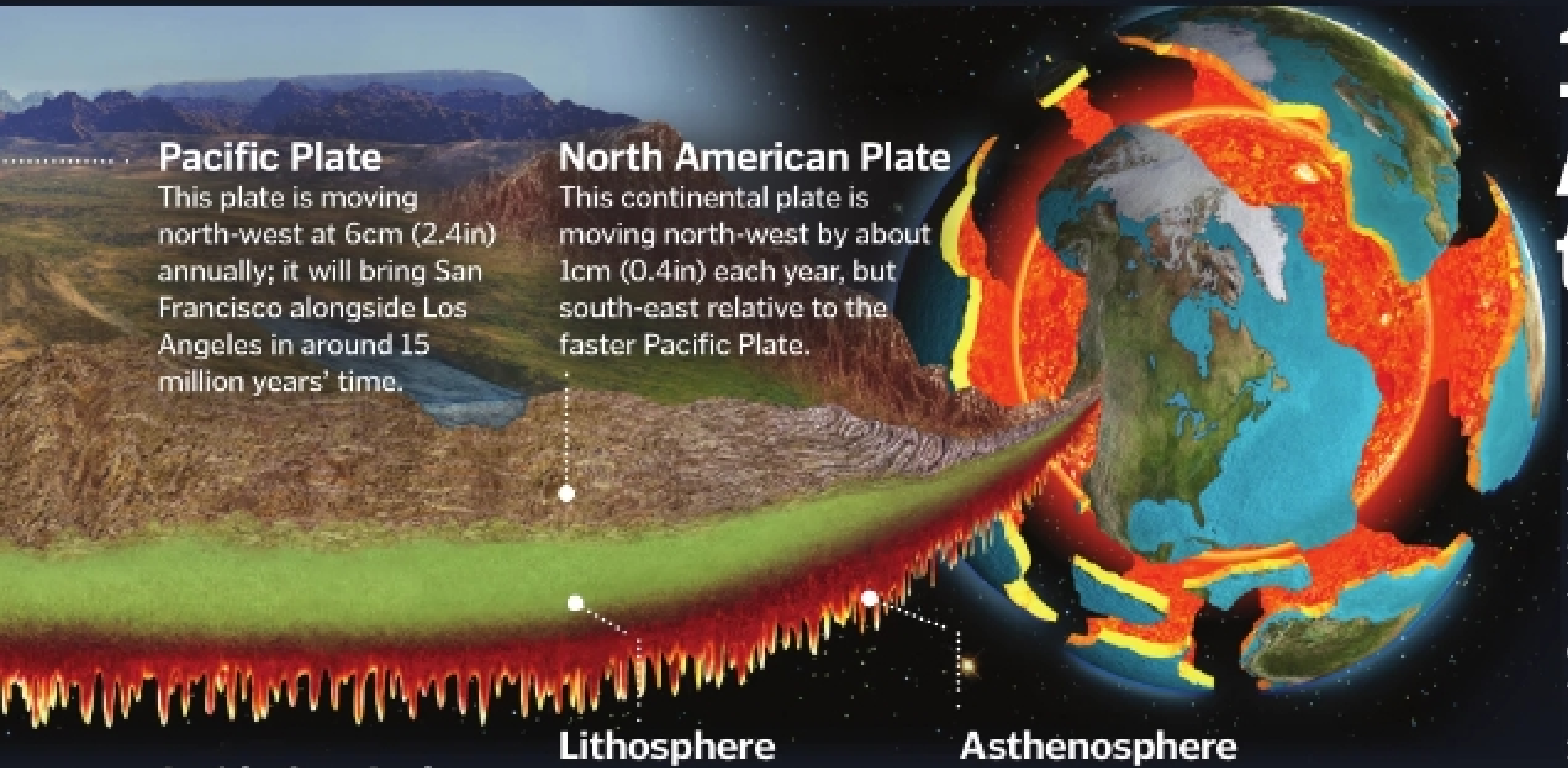
Secondary (shear) waves
S-waves lag behind P-waves as they travel 1.7 times slower and can only pass through solid rock. However they do more damage because they're bigger and shake the ground vertically *and* horizontally.



17. Do earthquakes happen off Earth?

There's evidence of 'marsquakes' on Mars as well as quakes on Venus. Several moons of Jupiter and Titan – a moon of Saturn – also show signs of quakes. Seismometers on the Moon detected tidal 'moonquakes' caused by the pull of the Earth's gravity, vibrations from meteorite impacts and tremors caused by the Moon's cold crust warming after the two-week lunar night.





Pacific Plate
This plate is moving north-west at 6cm (2.4in) annually; it will bring San Francisco alongside Los Angeles in around 15 million years' time.

North American Plate
This continental plate is moving north-west by about 1cm (0.4in) each year, but south-east relative to the faster Pacific Plate.

Inside San Andreas
The fault is around 16km (10mi) deep and up to 1,600m (5,250ft) wide. Inside are small fractures and pulverised rock.

Lithosphere
The top of the mantle and crust together are known as the lithosphere, which is about 100km (62mi) thick.

Asthenosphere
About 100-350km (62-217mi) below Earth's surface is the asthenosphere, a layer of hot, weak mantle rocks that flow slowly.

18. Why is the San Andreas Fault prone to large quakes?

Longer faults have larger earthquakes, which explains why the strike-slip San Andreas Fault has had several quakes over magnitude 7. The San Andreas Fault extends 1,300 kilometres (800 miles) along the coast of California. When a fault ruptures, it 'unzips' along its length. Each section of the fault releases energy – the longer the fault, the more energy released and so the bigger the quake. Scientists believe the San Andreas Fault is overdue for a potential magnitude 8.1 earthquake over a 547-kilometre (340-mile) length. The southern segment has stayed static for more than a century, allowing enormous stresses to build.

19. Could Africa ever be split from Europe by an earthquake?

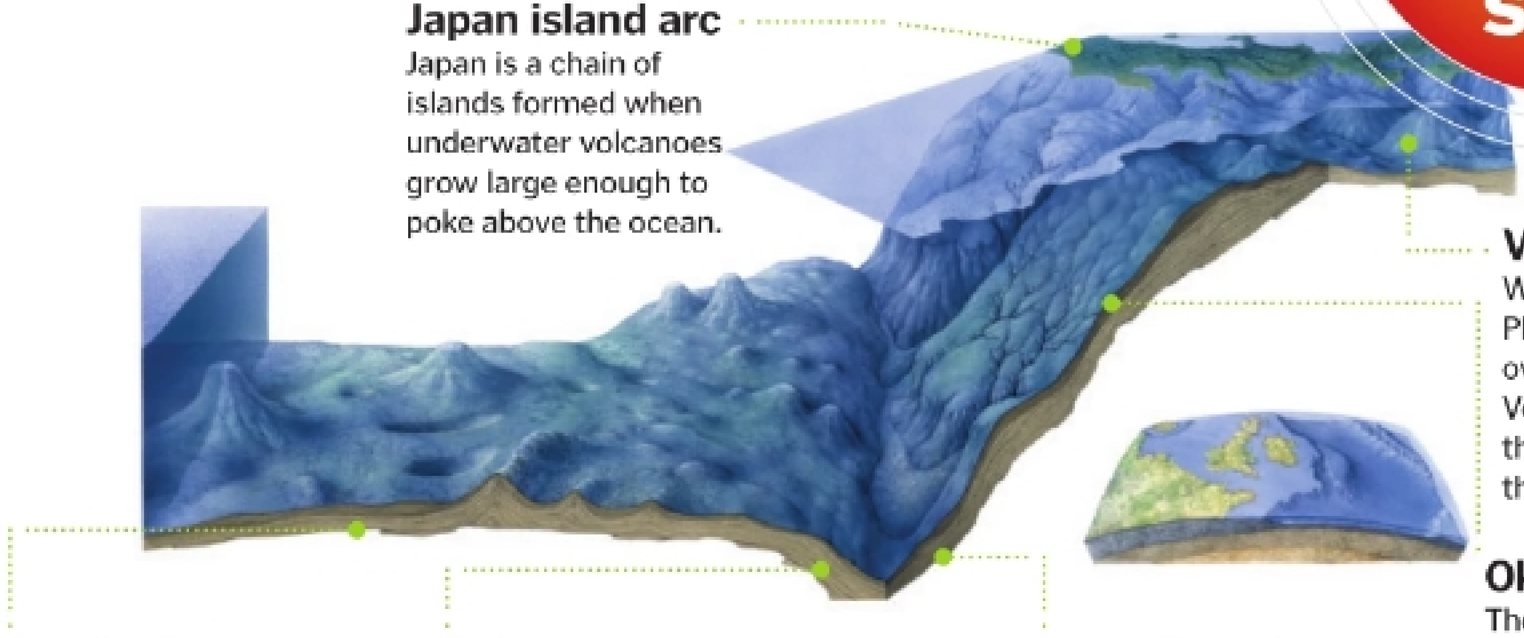
The Eurasian and African Plates are not splitting apart; they're actually moving towards each other at about one centimetre (0.4 inches) each year. In the future, it's possible that the Eurasian Plate may begin to slide beneath the African Plate. Even if the plates were moving apart, you'd need a mega-quake to yank Africa away from Europe in one go. There is no known fault long enough to create a mega-quake above magnitude 10. The most powerful earthquake in history was magnitude 9.5.

20. How many people jumping would it take to re-create the same reading as the Tohoku earthquake?

You'd need a million times Earth's population, all jumping at once, to generate the energy released by the March 2011 Tohoku quake. How do you calculate that? You assume Earth's population is 10 billion and each person generates 200 joules of energy by jumping 0.3 metres (0.98 feet).

21. How did the Japan Trench form?

A 390-kilometre (242-mile) stretch of the Japan Trench is associated with Japan's 2011 Tohoku earthquake. The trench is a vast chasm in Earth's crust at the junction between the Pacific Plate and tiny Okhotsk Plate beneath Japan. The Pacific Plate is moving westwards and diving beneath the Okhotsk. Friction between the two plates causes them to lock together and pressure to build. Sudden slippages release the tension in a violent burst of energy.



Japan island arc
Japan is a chain of islands formed when underwater volcanoes grow large enough to poke above the ocean.

Volcano
Water from the Pacific Plate helps melt overlying mantle rocks. Volcanoes form when this rock explodes through the crust.

Okhotsk Plate
The Okhotsk is a continental plate that lies beneath the northern part of Japan.

Pacific Plate
The oceanic Pacific Plate hits the much smaller Okhotsk Plate as it moves west towards Japan.

Subduction zone
The Pacific Plate slides beneath the Okhotsk Plate because it is made of denser oceanic crust.

Japan Trench
The trench is one of the deepest points in the world's oceans, up to 9km (5.6mi) below sea level.

22. How long do quakes last?

10-30 secs

23 Can animals predict quakes?

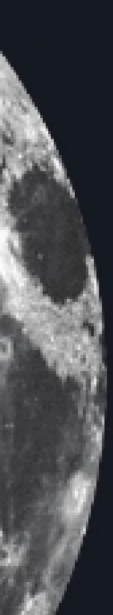
There's little evidence for whether animals can predict earthquakes, but many stories exist of odd behaviour. These include hibernating snakes fleeing their burrows in China in 1975, a month before the Haicheng quake.

24 Where is the safest place to be during an earthquake?

The safest place inside is underneath a sturdy table, away from light fittings and windows. The safest place outside is out in the open away from any buildings and electricity cables.

25 If I were stood on a beach during an earthquake would I sink?

Perhaps, but it's unlikely you would drown. During an earthquake, wet sand or soil can behave like quicksand – a process called liquefaction. A quake vibrates the sand, separating the grains so that they flow like a liquid. It's extremely unusual and even then people will rarely sink below their chests during liquefaction as they will float.



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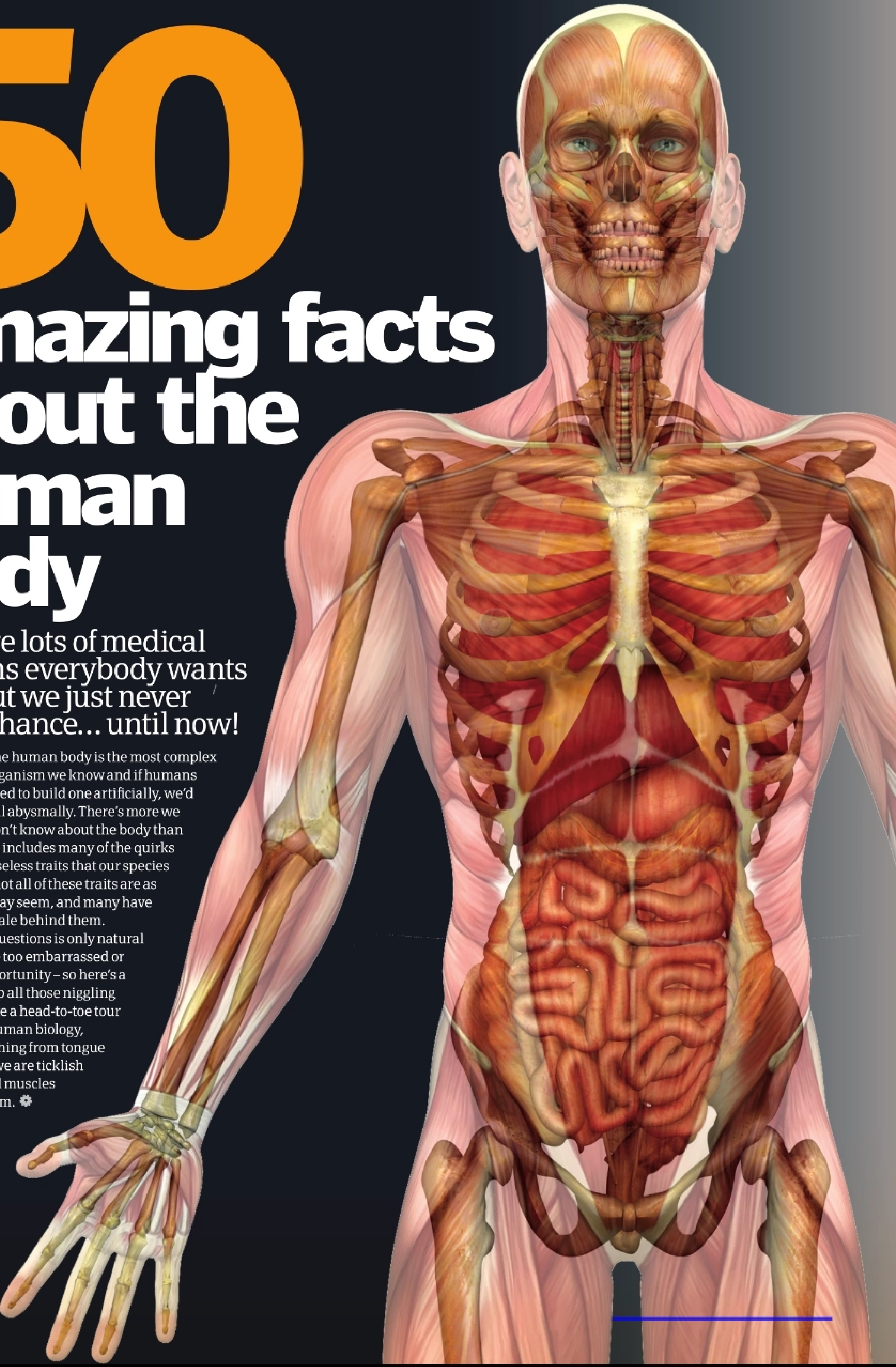
50
Amazing facts about the human body

There are lots of medical questions everybody wants to ask but we just never get the chance… until now!

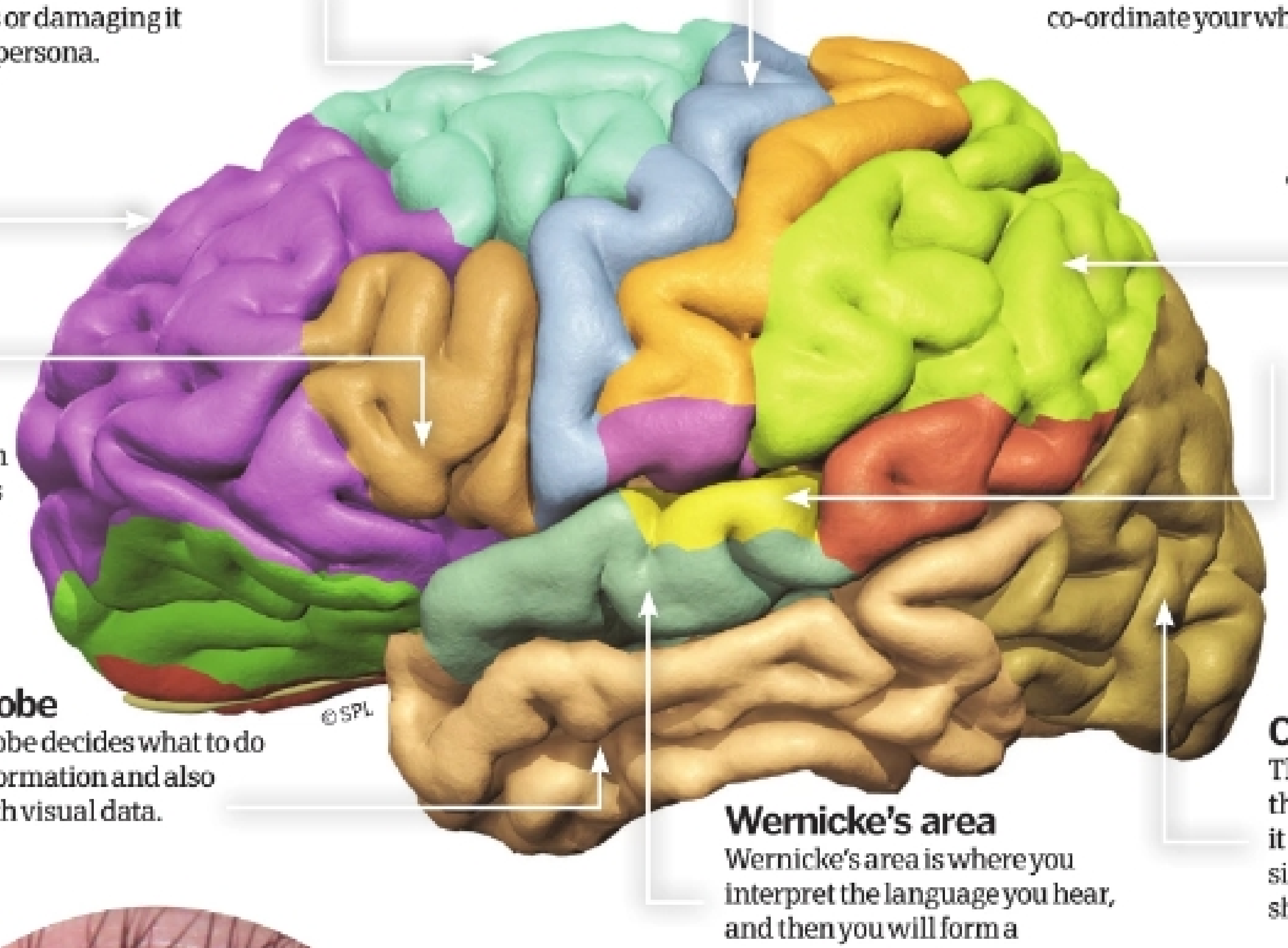
The human body is the most complex organism we know and if humans tried to build one artificially, we'd fail abysmally. There's more we don't know about the body than we do know. This includes many of the quirks and seemingly useless traits that our species carry. However, not all of these traits are as bizarre as they may seem, and many have an evolutionary tale behind them.

Asking these questions is only natural but most of us are too embarrassed or never get the opportunity – so here's a chance to clear up all those niggling queries. We'll take a head-to-toe tour of the quirks of human biology, looking at everything from tongue rolling and why we are ticklish through to pulled muscles and why we dream. ✱



1 How do we think?

What are thoughts? This question will keep scientists, doctors and philosophers busy for decades to come. It all depends how you want to define the term 'thoughts'. Scientists may talk about synapse formation, pattern recognition and cerebral activation in response to a stimulus (such as seeing an apple and recognising it as such). Philosophers, and also many scientists, will argue that a network of neurons cannot possibly explain the many thousands of thoughts and emotions that we must deal with. A sports doctor might state that when you choose to run, you activate a series of well-trodden pathways that lead from your brain to your muscles in less than a second. There are some specifics we do know though – such as which areas of your brain are responsible for various types of thoughts and decisions.



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Frontal lobe
The frontal lobe is where your personality is, and where your thoughts and emotions form. Removing this or damaging it can alter your persona.

Pre-motor cortex
The pre-motor cortex is where some of your movements are co-ordinated.

Primary motor cortex
The primary motor cortex and the primary somatosensory cortex are the areas which receive sensory innervations and then co-ordinate your whole range of movements.

Parietal lobe
The parietal lobe is responsible for your complex sensory system.

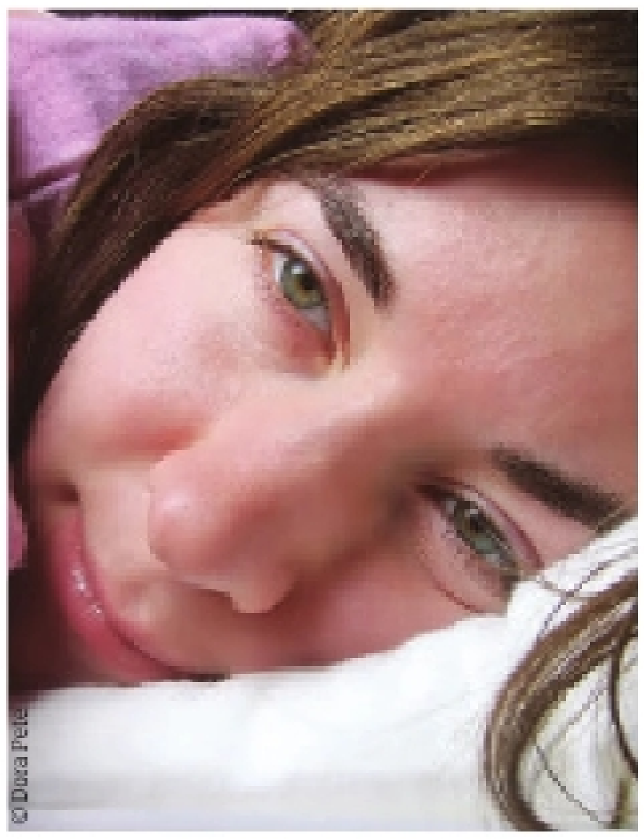
Broca's area
Broca's area is where you form complex words and speech patterns.

Primary auditory complex
The primary auditory complex is right next to the ear and is where you interpret sound waves into meaningful information.

Temporal lobe
The temporal lobe decides what to do with sound information and also combines it with visual data.

Occipital lobe
The occipital lobe is all the way at the back, but it interprets the light signals in your eyes into shapes and patterns.

Wernicke's area
Wernicke's area is where you interpret the language you hear, and then you will form a response via Broca's area.



© Dora Pete

2 In the mornings, do we wake up or open our eyes first?

Sleep is a gift from nature, which is more complex than you think. There are five stages of sleep which represent the increasing depths of sleep – when you're suddenly wide awake and your eyes spring open, it's often a natural awakening and you're coming out of rapid eye movement (REM) sleep; you may well remember your dreams. If you're coming out of a different phase, eg when your alarm clock goes off, it will take longer and you might not want to open your eyes straight away!

3 Do eyeballs grow like the rest of the body?

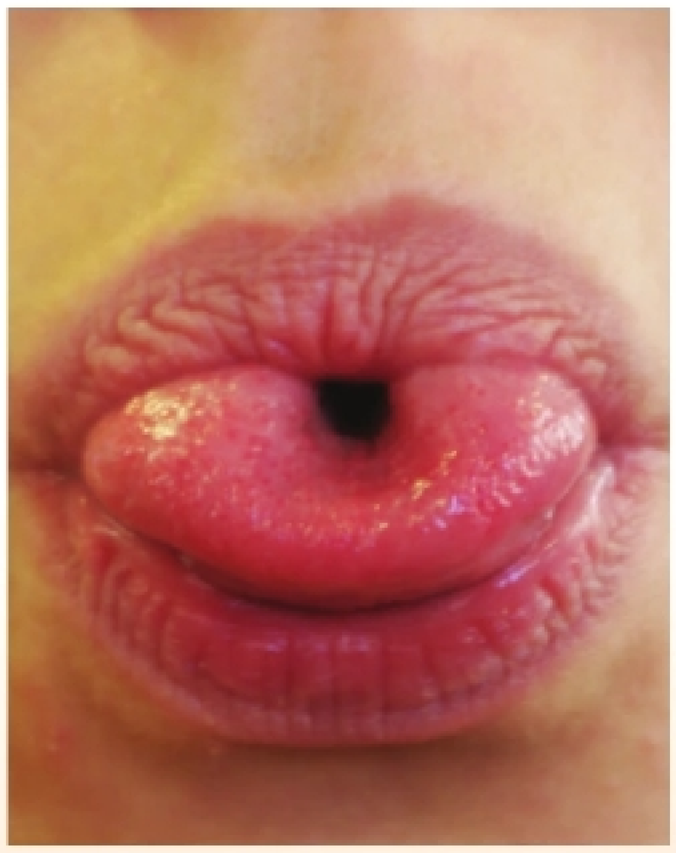
Only a small amount – hence why babies appear so beautiful, as their eyes are slightly out of proportion and so appear bigger.

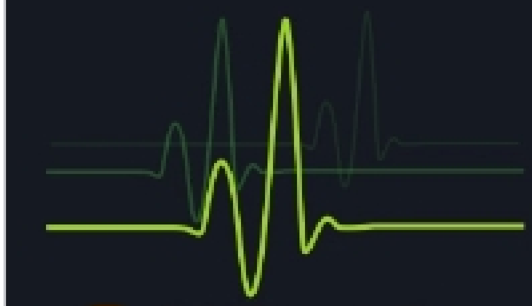
4 Why do we fiddle subconsciously? I'm constantly playing with my hair

This is a behavioural response – some people play with their hair when they're nervous or bored. For the vast majority of people such traits are perfectly normal; if they begin to interfere with your life, behavioural psychologists can help – but it's extremely rare that you'll end up there.

5 Why can some people roll their tongues but others can't?

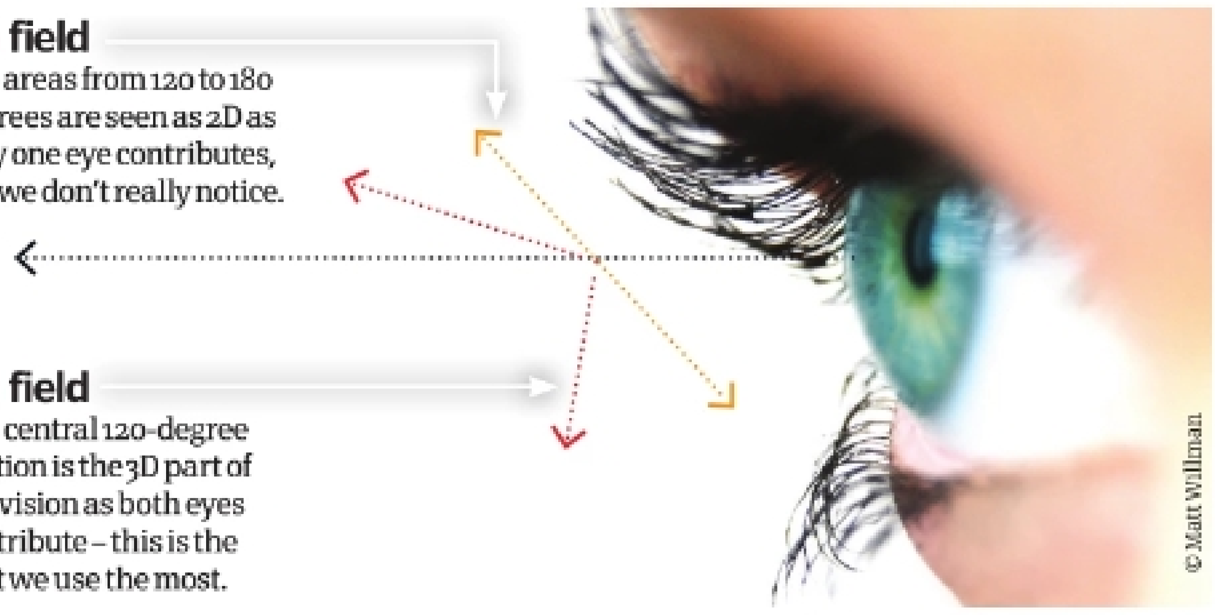
Although we're often taught in school that tongue rolling is due to genes, the truth is likely to be more complex. There is likely to be an overlap of genetic factors and environmental influence. Studies on families and twins have shown that it cannot be a case of simple genetic inheritance. Ask around – the fact that some people can learn to do it suggests that in at least some people it's environmental (ie a learned behaviour) rather than genetic (inborn).





6 What is a pulse?

When you feel your own pulse, you're feeling the direct transmission of your heartbeat down an artery. You can feel a pulse where you can compress an artery against a bone, eg the radial artery at the wrist. The carotid artery can be felt against the vertebral body but beware – a) press too hard and you can faint, b) press both at the same time and you'll cut off the blood to your brain and, as a protective mechanism, you'll definitely faint!



2D field
The areas from 120 to 180 degrees are seen as 2D as only one eye contributes, but we don't really notice.

3D field
The central 120-degree portion is the 3D part of our vision as both eyes contribute – this is the part we use the most.

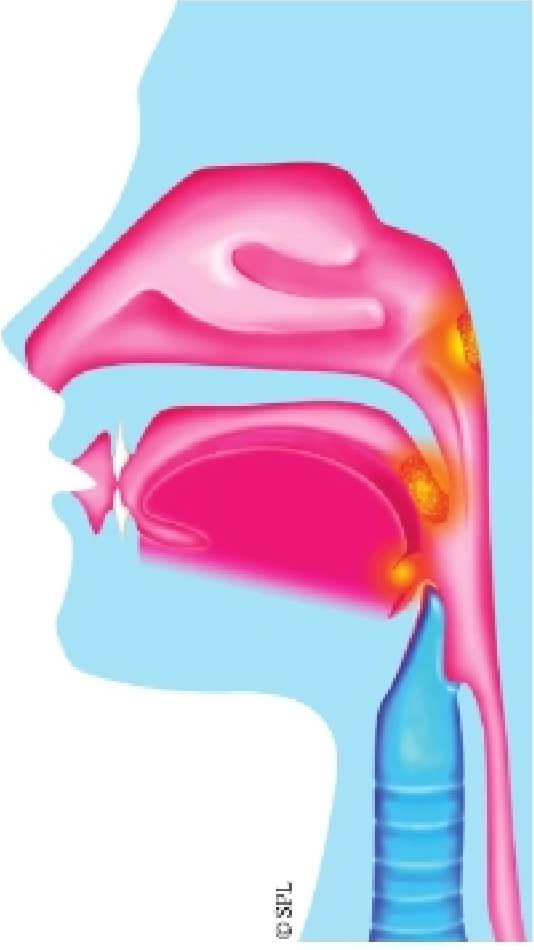
© Matt Willman

7 What's my field of vision in degrees?

The human field of vision is just about 180 degrees. The central portion of this (approximately 120 degrees) is binocular or stereoscopic – ie both eyes contribute, allowing depth perception so that we can see in 3D. The peripheral edges are monocular, meaning that there is no overlap from the other eye so we see in 2D.

8 What is the point of tonsils?

The tonsils are collections of lymphatic tissues which are thought to help fight off pathogens from the upper respiratory tract. However, they themselves can sometimes become infected – leading to tonsillitis. The ones you can see at the back of your throat are just part of the ring of tonsils. You won't miss them if they're taken out for recurrent infections as the rest of your immune system will compensate.



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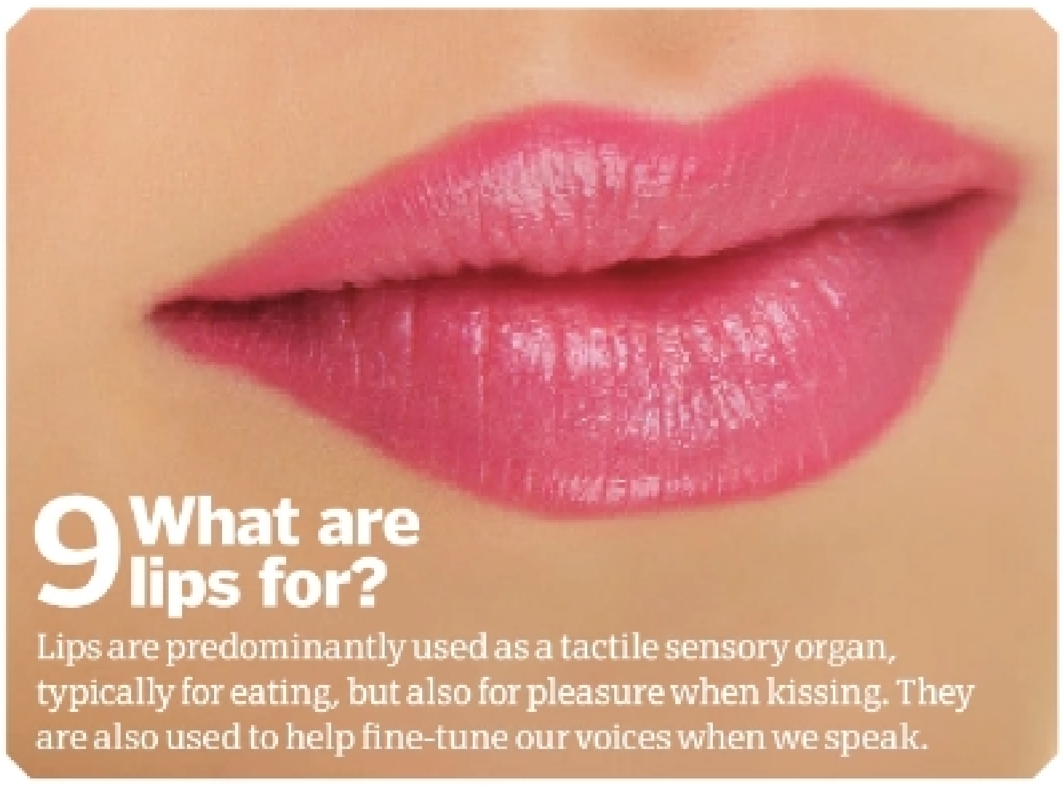
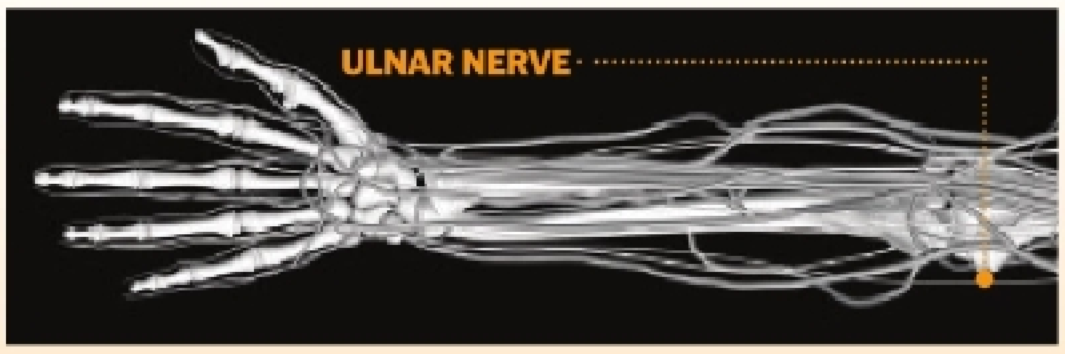


9 What are lips for?

Lips are predominantly used as a tactile sensory organ, typically for eating, but also for pleasure when kissing. They are also used to help fine-tune our voices when we speak.

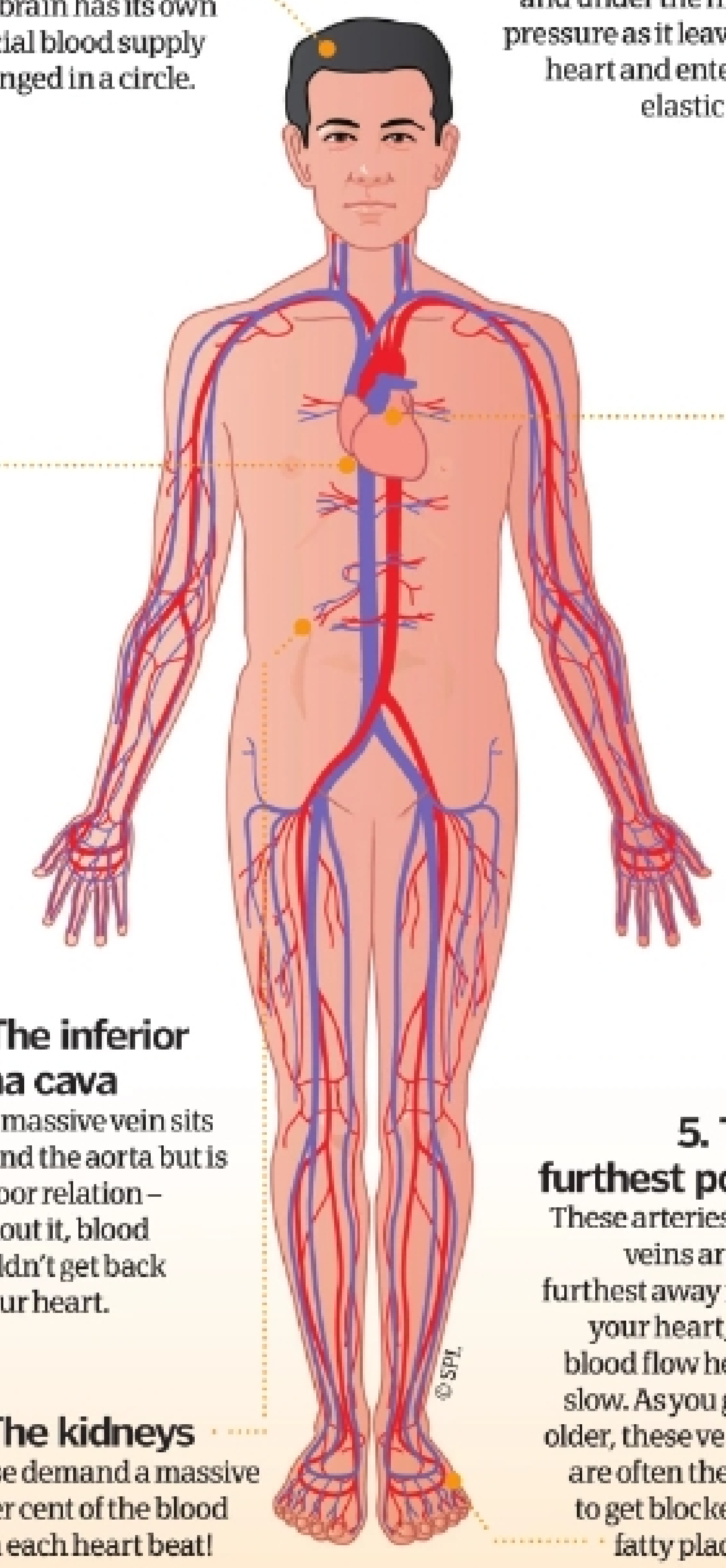
10 Why does it feel so weird when you hit your funny bone?

You're actually hitting the ulnar nerve as it wraps around the bony prominence of the 'humerus' bone, leading to a 'funny' sensation. Although not so funny as the brain interprets this sudden trauma as pain to your forearm and fingers!



11 How fast does blood travel round the human body?

Your total 'circulating volume' is about five litres. Each red blood cell within this has to go from your heart, down the motorway-like arteries, through the back-road capillary system, and then back through the rush-hour veins to get back to your heart. The process typically takes about a minute. When you're in a rush and your heart rate shoots up, the time reduces as the blood diverts from the less-important structures (eg large bowel) to the more essential (eg muscles).



1. The most important organ
The brain has its own special blood supply arranged in a circle.

2. Under pressure
Blood is moving fastest and under the highest pressure as it leaves the heart and enters the elastic aorta.

3. The kidneys
These demand a massive 25 per cent of the blood from each heart beat!

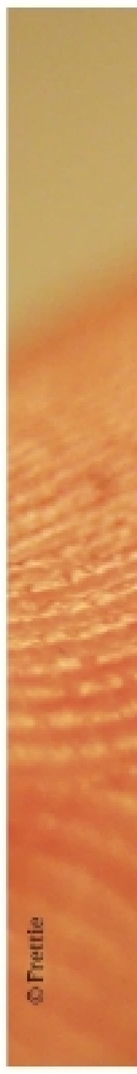
4. The inferior vena cava
This massive vein sits behind the aorta but is no poor relation – without it, blood wouldn't get back to your heart.

5. The furthest point
These arteries and veins are the furthest away from your heart, and blood flow here is slow. As you grow older, these vessels are often the first to get blocked by fatty plaques.

© SPL

12 Why do we burp?

A burp is a natural release of gas from the stomach. This gas has either been swallowed or is the result of something you've ingested – such as a fizzy drink. The sound comes from the vibration of the oesophageal sphincter at the oesophago-gastric junction, which is the narrowest part of the gastrointestinal tract.



© Frettie

13

It's different for everybody – your age, nutrition, health status, genes and gender all play a role. In terms of length, anywhere between 0.5-1 inch (1.2-2.5cm) a month might be considered average, but don't be surprised if you're outside this range.

14 Why are everyone's fingerprints different?

Your fingerprints are fine ridges of skin in the tips of your fingers and toes. They are useful for improving the detection of small vibrations and to add friction for better grip. No two fingerprints are the same – either on your hands or between two people – and that's down to your unique set of genes.

© Tristanb

15 Why do we only remember some dreams?

Dreams have fascinated humans for thousands of years. Some people think they are harmless while others think they are vital to our emotional wellbeing. Most people have four to eight dreams per night which are influenced by stress, anxiety and desires, but they remember very few of them. There is research to prove that if you awake from the rapid eye movement (REM) part of your sleep cycle, you're likely to remember your dreams more clearly.

16 Why, as we get older, does hair growth become so erratic?

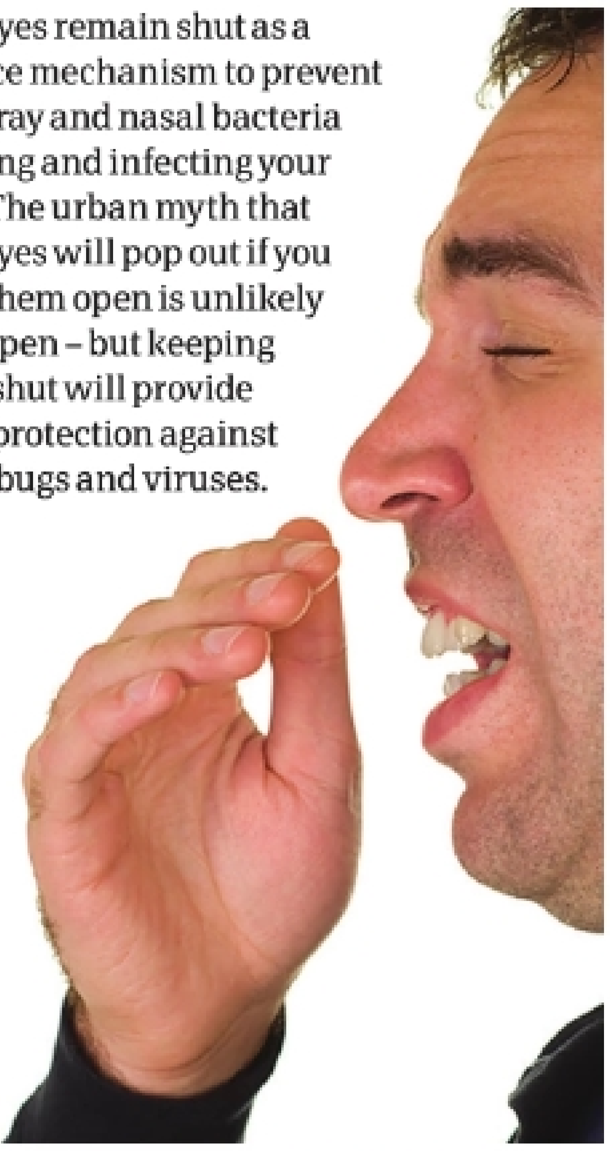
Hair follicles in different parts of your body are programmed by your genes to do different things, eg the follicles on your arm produce hair much slower than those on your head. Men can go bald due to a combination of genes and hormonal changes, which may not happen in other areas (eg nasal hair). It's different for everybody!

17 Why do we all have different coloured hair?

Most of it is down to the genes that result from when your parents come together to make you. Some hair colours win out (typically the dark ones) whereas some (eg blonde) are less strong in the genetic race.

18 Is it possible to keep your eyes open when you sneeze?

Your eyes remain shut as a defence mechanism to prevent the spray and nasal bacteria entering and infecting your eyes. The urban myth that your eyes will pop out if you keep them open is unlikely to happen – but keeping them shut will provide some protection against nasty bugs and viruses.



19 What gives me my personality?

Researchers have spent their whole lives trying to answer this one. Your personality forms in the front lobes of your brain, and there are clear personality types. Most of it is your environment – that is, your upbringing, education, surroundings. However some of it is genetic, although it's unclear how much. The strongest research in this comes from studying twins – what influences one set of twins to grow up and be best friends, yet in another pair, one might become a professor and the other a murderer.

20 WHY DO MEN HAVE NIPPLES?

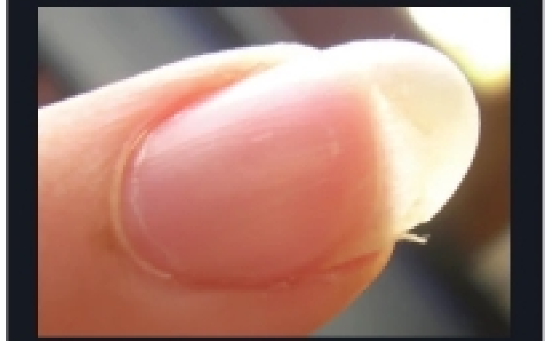
Men and women are built from the same template, and these are just a remnant of a man's early development.

21 WHAT'S THE POINT OF EYEBROWS?

Biologically, eyebrows can help to keep sweat and rainwater from falling into your eyes. More importantly in humans, they are key aids to non-verbal communication.

22 WHAT IS A BELLY BUTTON?

The umbilicus is where a baby's blood flows through to get to the placenta to exchange oxygen and nutrients with the mother's blood. Once out, the umbilical cord is clamped several centimetres away from the baby and left to fall off. No one quite knows why you'll get an 'innie' or an 'outie' – it's probably all just luck.



23 WHY DO FINGERNAILS GROW FASTER THAN TOENAILS?

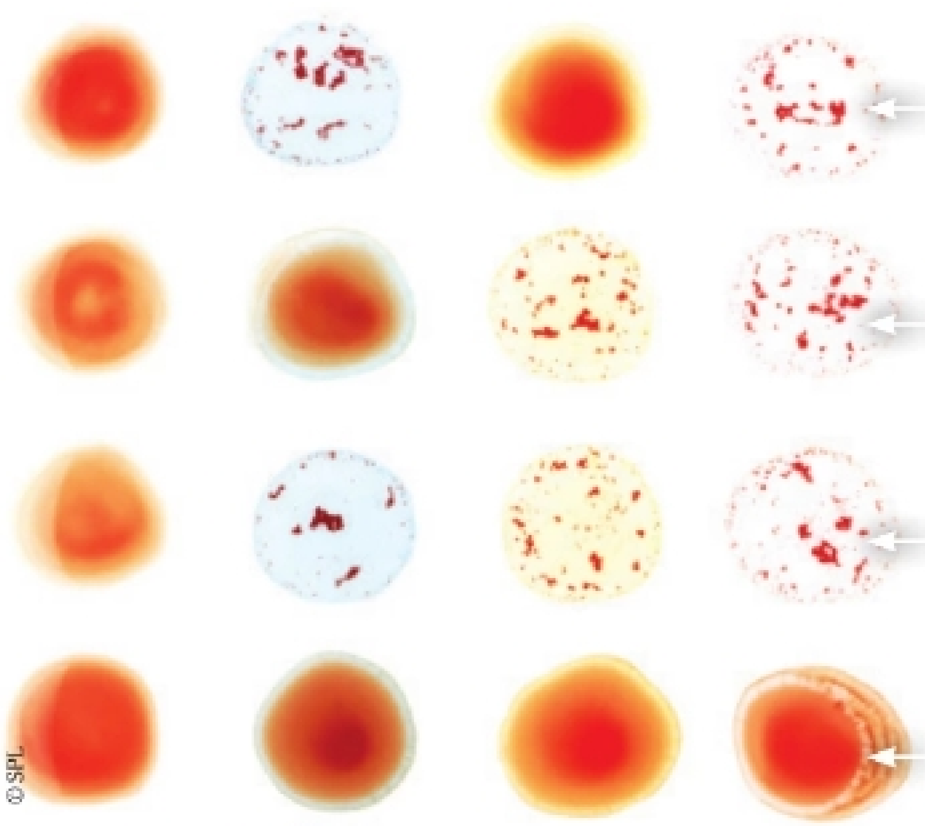
The longer the bone at the end of a digit, the faster the growth rate of the nail. However there are many other influences too – nutrition, sun exposure, activity, blood supply – and that's just to name a few.

24 WHY DOES MY ARM TINGLE AND FEEL HEAVY IF I FALL ASLEEP ON IT?

This happens because you're compressing a nerve as you're lying on your arm. There are several nerves supplying the skin of your arm and three supplying your hand (the radial, median and ulnar nerves), so depending on which part of your arm you lie on, you might tingle in your forearm, hand or fingers.

25 What makes some blood groups incompatible while others are universal?

Your blood type is determined by protein markers known as antigens on the surface of your red blood cells. You can have A antigens, B antigens, or none – in which case you're blood type O. However, if you don't have the antigen, your antibodies will attack foreign blood. If you're type A and you're given B, your antibodies attack the B antigens. However, if you're blood type AB, you can safely receive any type. Those who are blood group O have no antigens so can give blood to anyone, but they have antibodies to A and B so can only receive O back!



A
You have A antigens and B antibodies. You can receive blood groups A and O, but can't receive B. You can donate to A and AB.

B
You have B antigens and A antibodies. You can receive blood groups B and O, but can't receive A. You can donate to B and AB.

AB
You have A and B antigens and no antibodies. You can receive blood groups A, B, AB and O (universal recipient), and can donate to AB.

O
You have no antigens but have A and B antibodies. You can receive blood group O, but can't receive A, B or AB and can donate to all: A, B, AB and O.

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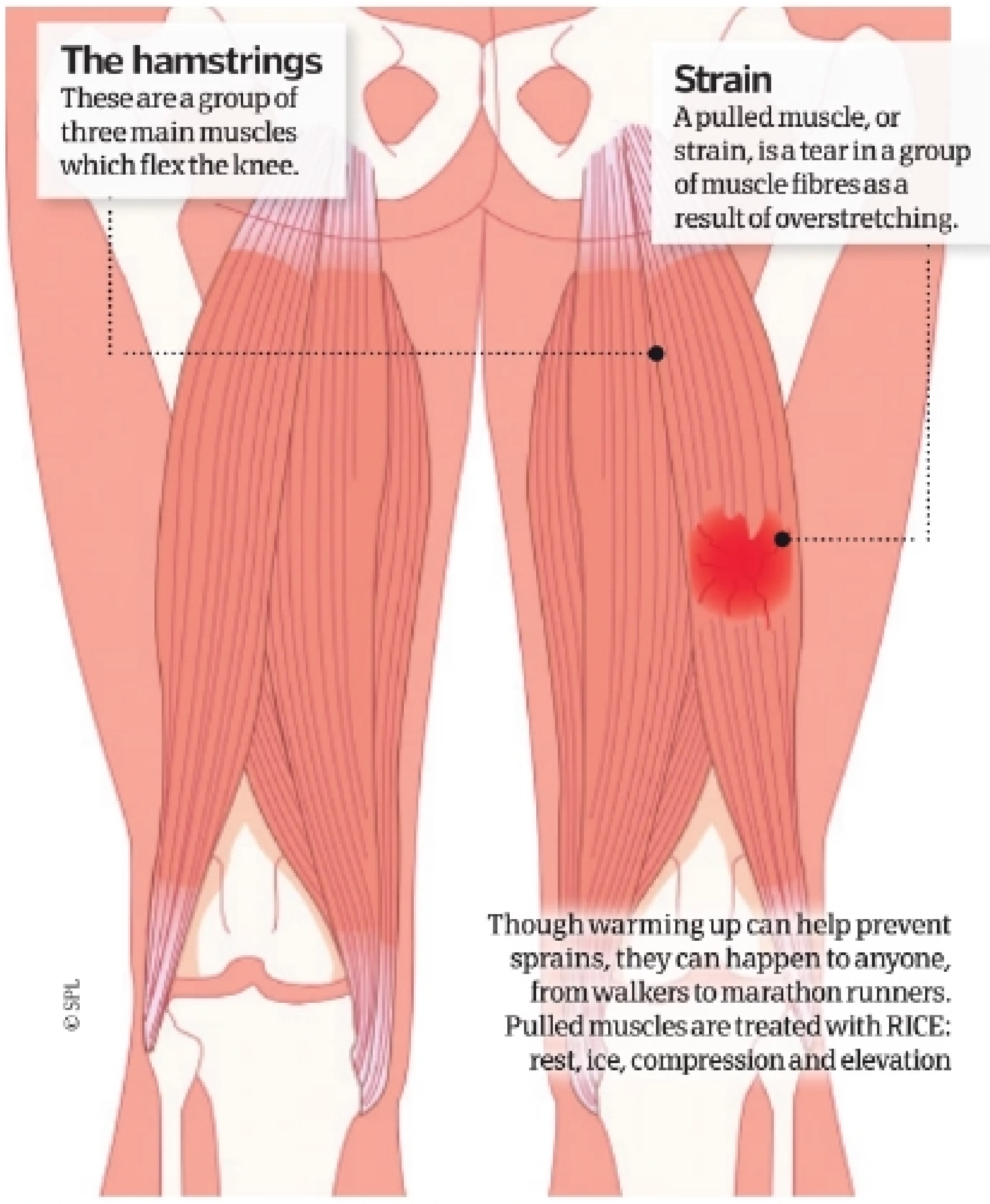
26 What is a pulled muscle?



The hamstrings
These are a group of three main muscles which flex the knee.

Strain
A pulled muscle, or strain, is a tear in a group of muscle fibres as a result of overstretching.

Though warming up can help prevent sprains, they can happen to anyone, from walkers to marathon runners. Pulled muscles are treated with RICE: rest, ice, compression and elevation

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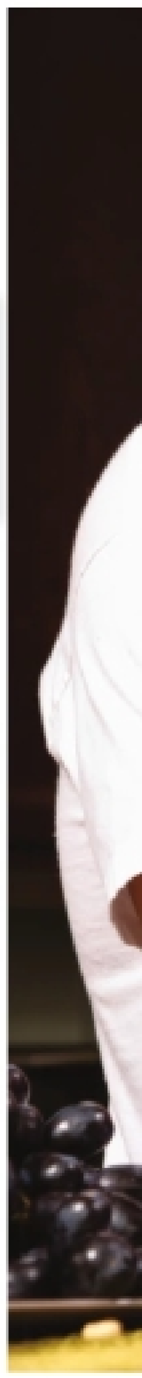
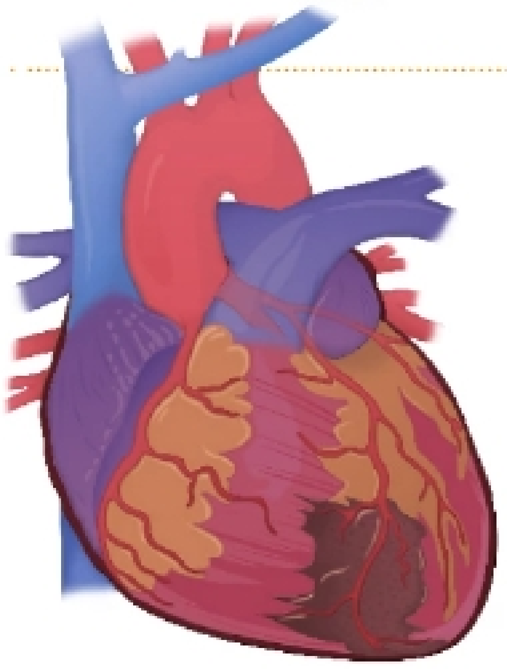


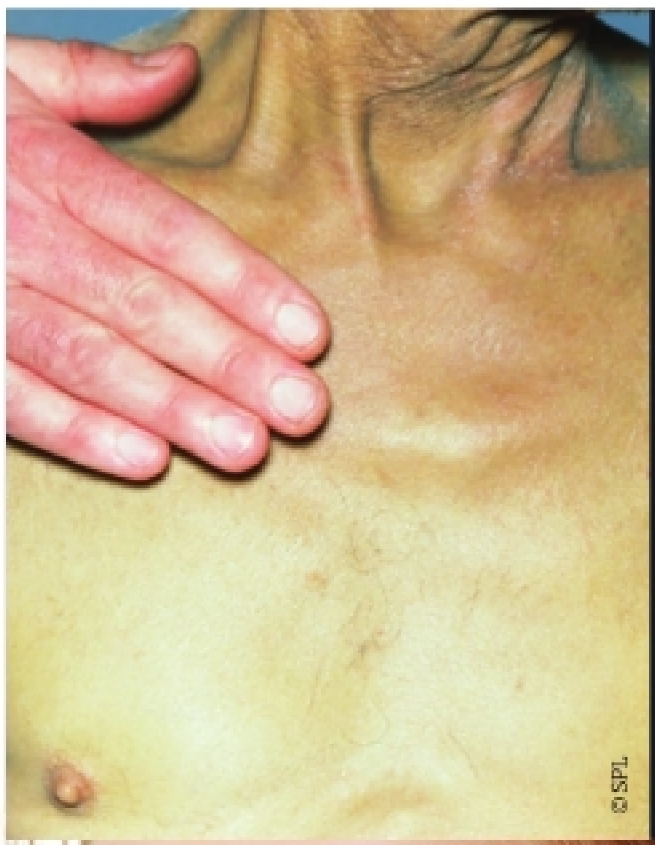


27 Which organ uses up the most oxygen?

The heart is the most efficient – it extracts 80 per cent of the oxygen from blood. But the liver gets the most blood – 40 per cent of the cardiac output compared to the kidneys, which get 25 per cent, and heart, which only receives 5 per cent.

28 What is the appendix? I've heard it has no use but can kill you…

The appendix is useful in cows for digesting grass and koala bears for digesting eucalyptus – koalas can have a 4m (13ft)-long appendix! In humans, however, the appendix has no useful function and is a remnant of our development. It typically measures 5-10cm (1.9-3.9in), but if it gets blocked it can get inflamed. If it isn't quickly removed, the appendix can burst and lead to widespread infection which can be lethal.



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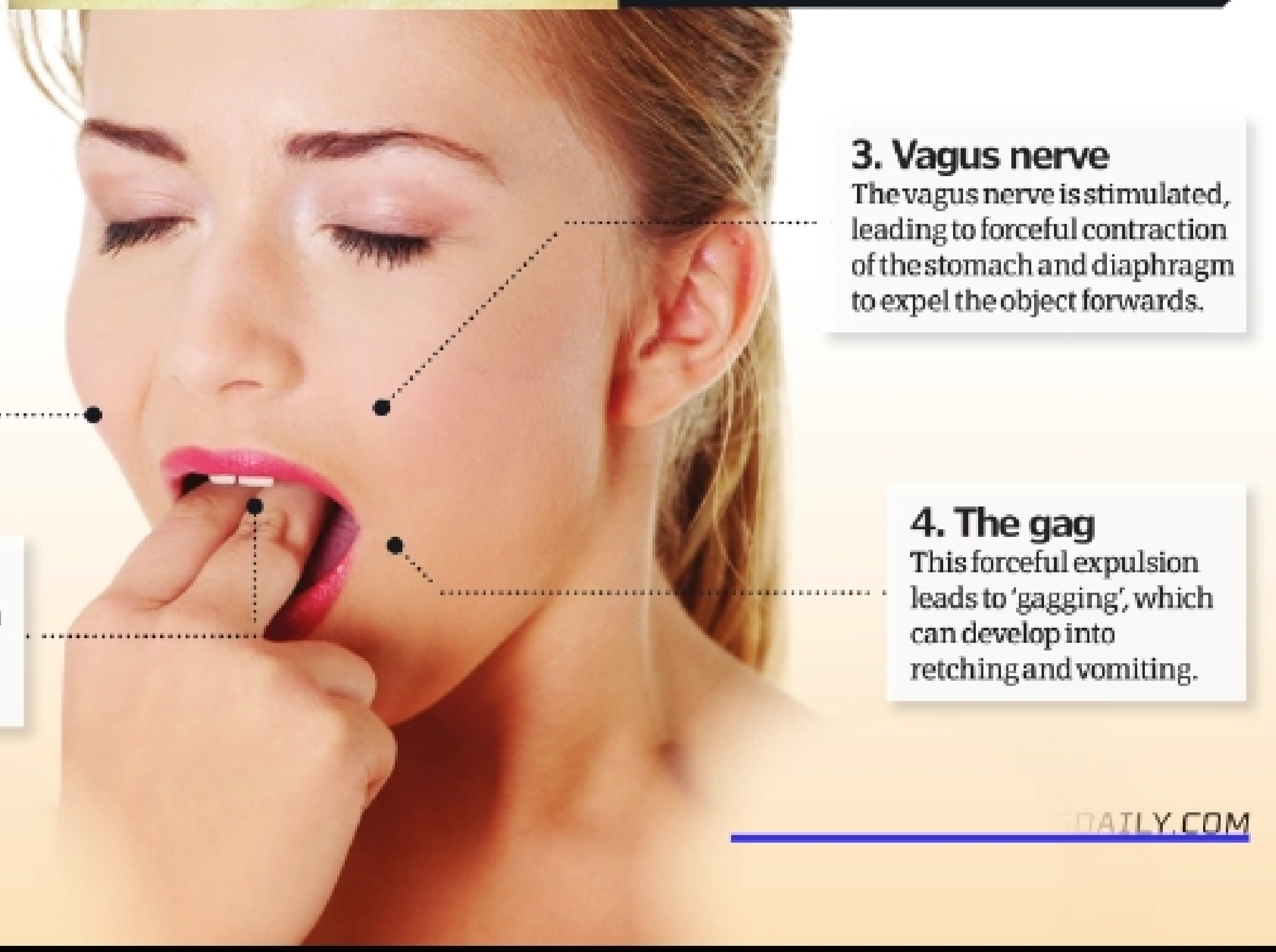
29 Why does people's skin turn yellow if they contract liver disease?

This yellow discolouration of the skin or the whites of the eyes is called jaundice. It's due to a buildup of bilirubin in your body, when normally this is excreted in the urine (hence why urine has a yellow tint). Diseases such as hepatitis and gallstones can lead to a buildup of bilirubin due to altered physiological processes, although there are many other causes.

30 What is the gag reflex?



1. Foreign bodies
This is a protective mechanism to prevent food or foreign bodies entering the back of the throat at times other than swallowing.

2. Soft palate
The soft palate (the fleshy part of the mouth roof) is stimulated, sending signals down the glossopharyngeal nerve.

3. Vagus nerve
The vagus nerve is stimulated, leading to forceful contraction of the stomach and diaphragm to expel the object forwards.

4. The gag
This forceful expulsion leads to 'gagging', which can develop into retching and vomiting.

31 Why are we ticklish?

Light touches, by feathers, spiders, insects or other humans, can stimulate fine nerve-endings in the skin which send impulses to the somatosensory cortex in the brain. Certain areas are more ticklish – such as the feet – which may indicate that it is a defence mechanism against unexpected predators. It is the unexpected nature of this stimulus that means you can be tickled. Although you can give yourself goosebumps through light tickling, you can't make yourself laugh.

32 Why don't eyelashes keep growing?

Your eyelashes are formed from hair follicles, just like those on your head, arms and body. Each follicle is genetically programmed to function differently. Your eyelashes are programmed to grow to a certain length and even re-grow if they fall out, but they won't grow beyond a certain length, which is handy for seeing!

© shlomitg

33 What makes us left-handed?

One side of the brain is typically dominant over the other. Since each hemisphere of the brain controls the opposite side (ie the left controls the right side of your body), right-handed people have stronger left brain hemispheres. Occasionally you'll find an ambidextrous person, where hemispheres are co-dominant, and these people are equally capable with both right and left hands!

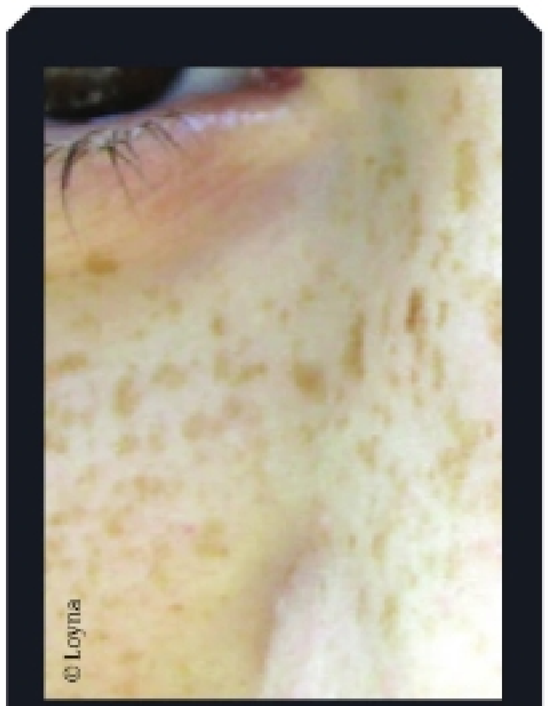
© Jenny Solis

34 Could we survive on vitamins alone?

No, you need a diet balanced in carbohydrate, protein, fat, vitamins and minerals to survive. You can't cut one of these and expect to stay healthy. However, it's the proportions of these which keep us healthy and fit. You can get these from the five major food groups. Food charts can help with this balancing act.

35 Why do we get a high temperature when we're ill?

The immune response leads to inflammation and the release of inflammatory factors into your blood stream. These lead to an increased heart rate and blood flow, which increases your core body temperature – as if your body is doing exercise. This can lead to increased heat production and thus dehydration; for this reason, it's important to drink plenty of clear fluids when you're feeling unwell.



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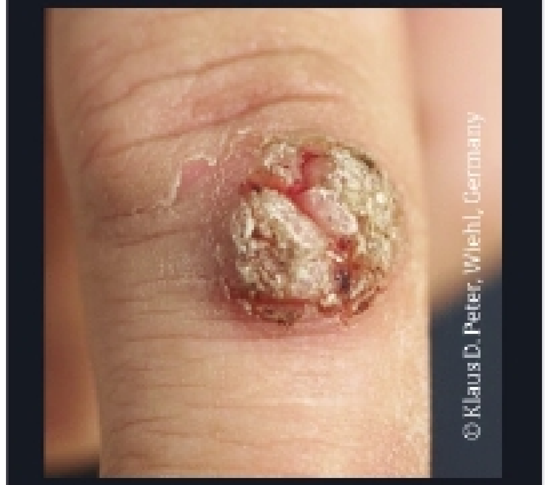
36 WHY DO SOME PEOPLE HAVE FRECKLES?

Freckles are concentrations of the dark skin pigment melanin in the skin. They typically occur on the face and shoulders, and are more common in light-skinned people. They are also a well-recognised genetic trait and become more dominant during sun-exposure.



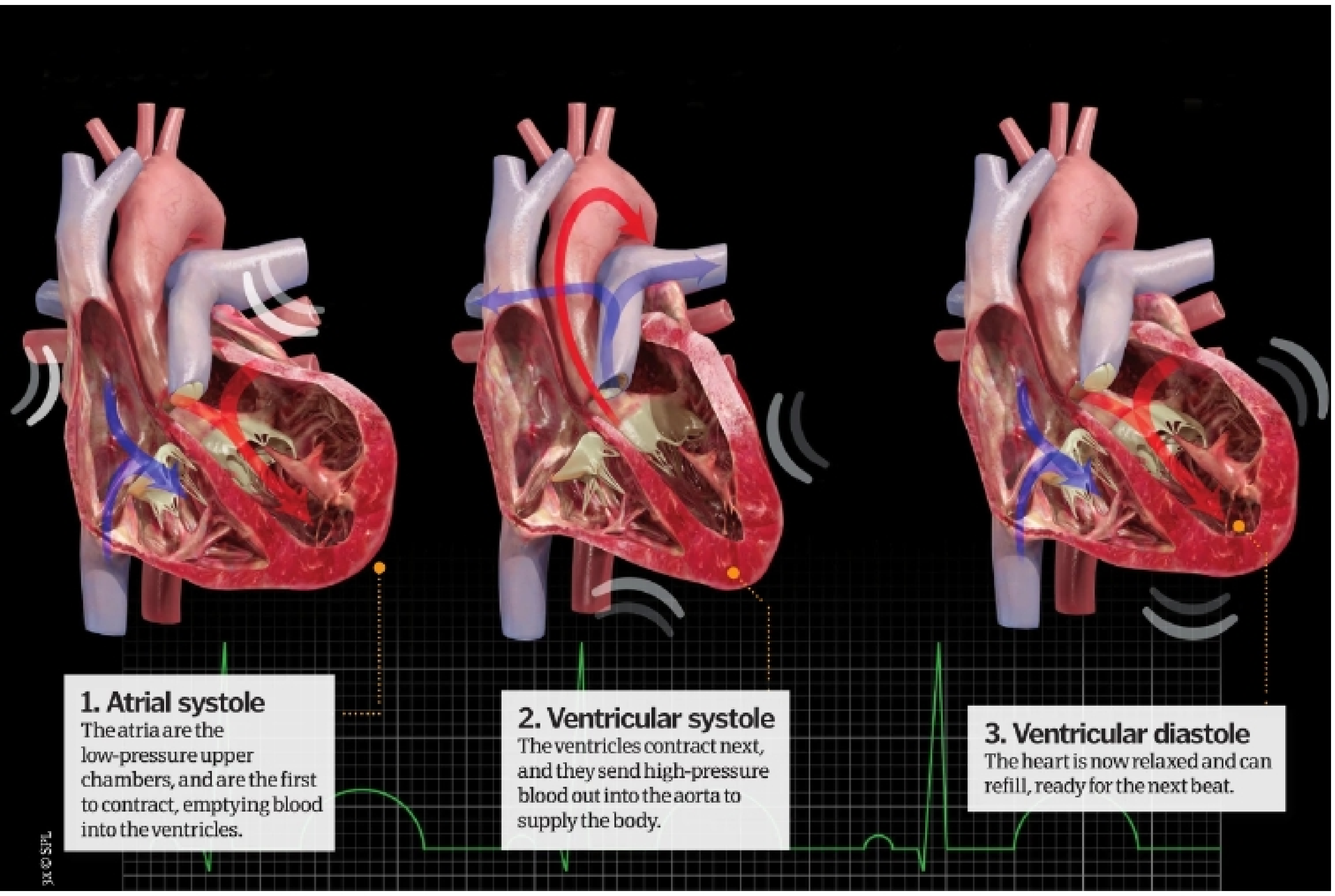
© Klaus D. Peter, Wiehl, Germany

37 WHAT IS A WART?

Warts are small, rough, round growths of the skin caused by the human papilloma virus. There are many different types which can occur in different parts of the body, and they can be contagious. They commonly occur on the hands, but can also come up anywhere from the genitals to the feet!

38 WHY DO I TWITCH IN MY SLEEP?

This is common and known in the medical world as a myoclonic twitch. Although some researchers say these twitches are associated with stress or caffeine use, they are likely to be a natural part of the sleep process. If it happens to you, it's perfectly normal.



1. Atrial systole
The atria are the low-pressure upper chambers, and are the first to contract, emptying blood into the ventricles.

2. Ventricular systole
The ventricles contract next, and they send high-pressure blood out into the aorta to supply the body.

3. Ventricular diastole
The heart is now relaxed and can refill, ready for the next beat.

3X © SPL

39 What triggers the heart and keeps it beating?

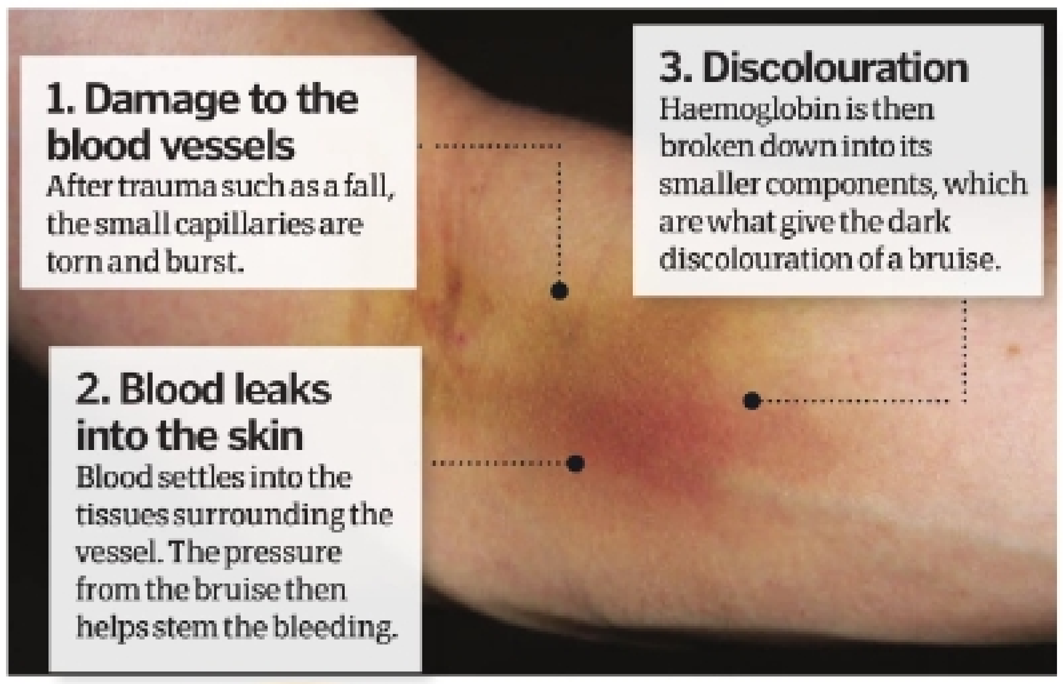
The heart keeps itself beating. The sinoatrial node (SAN) is in the wall of the right atrium of the heart, and is where the heartbeat starts. These beats occur due to changes in electrical currents as calcium, sodium and potassium move across membranes. The heart can beat at a rate of 60 beats per minute constantly if left alone. However – we often need it to go faster. The sympathetic nervous system sends rapid signals from the brain to stimulate the heart to beat faster when we need it to – in 'fight or flight' scenarios. If the SAN fails, a pacemaker can send artificial electrical signals to keep the heart going.

Definitions

Systole = contraction;
Diastole = relaxation

40 Why do bruises go purple or yellow?

A bruise forms when capillaries under the skin leak and allow blood to settle in the surrounding tissues. The haemoglobin in red blood cells is broken down, and these by-products give a dark yellow, brown or purple discolouration depending on the volume of blood and colour of the overlying skin. Despite popular belief, you cannot age a bruise – different people's bruises change colour at different rates.



1. Damage to the blood vessels
After trauma such as a fall, the small capillaries are torn and burst.

2. Blood leaks into the skin
Blood settles into the tissues surrounding the vessel. The pressure from the bruise then helps stem the bleeding.

3. Discolouration
Haemoglobin is then broken down into its smaller components, which are what give the dark discolouration of a bruise.

41 Why does cutting onions make us cry?

© Lali Masriera

Onions make your eyes water due to their expulsion of an irritant gas once cut. This occurs as when an onion is cut with a knife, many of its internal cells are broken down, allowing enzymes to break down amino acid sulphoxides and generate sulphenic acids. These sulphenic acids are then rearranged by another enzyme and, as a direct consequence, syn-propanethial-S-oxide gas is produced, which is volatile. This volatile gas then diffuses in the air surrounding the onion, eventually reaching the eyes of the cutter, where it proceeds to activate sensory neurons and create a stinging sensation. As such, the eyes then follow protocol and generate tears from their tear glands in order to dilute and remove the irritant. Interestingly, the volatile gas generated by cutting onions can be largely mitigated by submerging the onion in water prior to or midway through cutting, with the liquid absorbing much of the irritant.

44 Why do more men go bald than women?

'Simple' male pattern baldness is due to a combination of genetic factors and hormones. The most implicated hormone is testosterone, which men have high levels of but women have low levels of, so they win (or lose?) in this particular hormone contest!

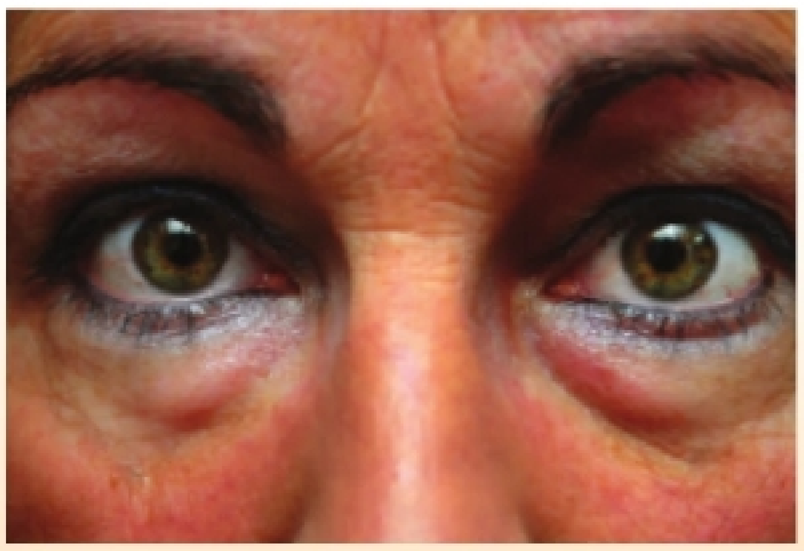
© David Benbennick

42 What is the little triangle shape on the side of the ear?

This is the tragus. It serves no major function that we know of, but it may help to reflect sounds into the ear to improve hearing.

43 When we're tired, why do we get bags under our eyes?

Blood doesn't circulate around your body as efficiently when you're asleep so excess water can pool under the eyes, making them puffy. Fatigue, nutrition, age and genes also cause bags.



45 Why do we blink?

Blinking helps keep your eyes clean and moist. Blinking spreads secretions from the tear glands (lacrimal fluids) over the surface of the eyeball, keeping it moist and also sweeping away small particles such as dust.

46 How come most people have one foot larger than the other?

Most people's feet are different sizes – in fact the two halves of most people's bodies are different! We all start from one cell, but as the cells multiply, genes give them varying characteristics.

47 Why do we get itchy?

Itching is caused by the release of a transmitter called histamine from mast cells which circulate in your body. These cells are often released in response to a stimulus, such as a bee sting or an allergic reaction. They lead to inflammation and swelling, and send impulses to the brain via nerves which causes the desire to itch.

48 Why do some hereditary conditions skip a generation?

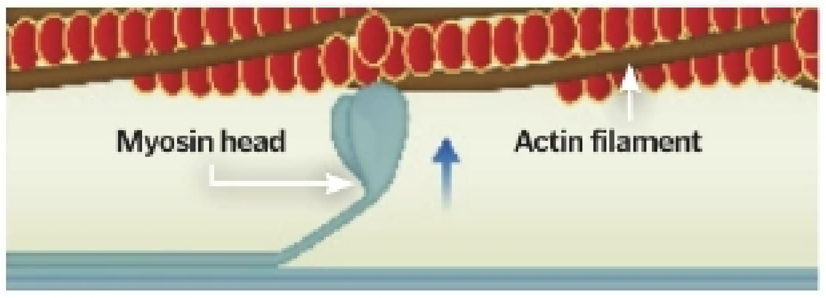
Genes work in pairs. Some genes are 'recessive' and if paired with a 'dominant' half, they won't shine through. However, if two recessive genes combine (one from your mother and one from your father), the recessive trait will show through.

49 Why do amputees sometimes still feel pain in their amputated limbs?

This is 'phantom limb pain' and can range from a mild annoyance to a debilitating pain. The brain can sometimes struggle to adjust to the loss of a limb, and it can still 'interpret' the limb as being there. Since the nerves have been cut, it interprets these new signals as pain. There isn't a surgical cure as yet, though time and special medications can help lessen the pain.

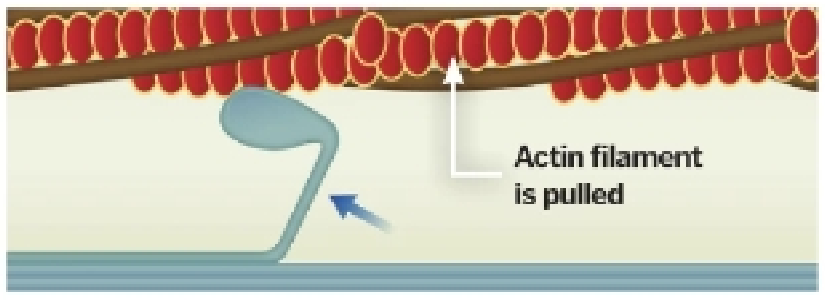
50 Which muscle produces the most powerful contraction relative to its size?

The gluteus maximus is the largest muscle and forms the bulk of your buttock. The heart (cardiac muscle) is the hardest-working muscle, as it is constantly beating and clearly can never take a break! However the strongest muscle based on weight is the masseter. This is the muscle that clenches the jaw shut – put a finger over the lowest, outer part of your jaw and clench your teeth and you'll feel it.



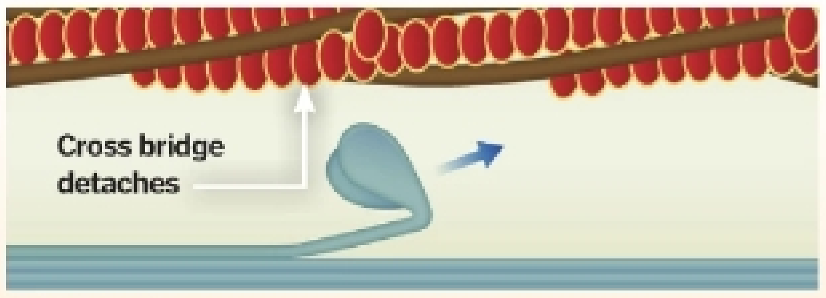
1. Taking the first step

Muscle contraction starts with an impulse received from the nerves supplying the muscle – an action potential. This action potential causes calcium ions to flood across the protein muscle fibres. The muscle fibres are formed from two key proteins: actin and myosin.



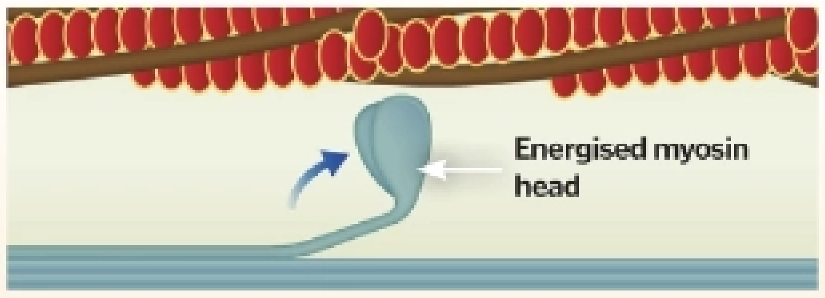
2. Preparation

The calcium binds to troponin which is a receptor on the actin protein. This binding changes the shape of tropomyosin, another protein which is bound to actin. These shape changes lead to the opening of a series of binding sites on the actin protein.



3. Binding

Now the binding sites are free on actin, the myosin heads forge strong bonds in these points. This leads to the contraction of the newly formed protein complex; when all of the proteins contract, the muscle bulk contracts.



4. Unbinding

When the energy runs out, the proteins lose their strong bonds and disengage, and from there they return to their original resting state.